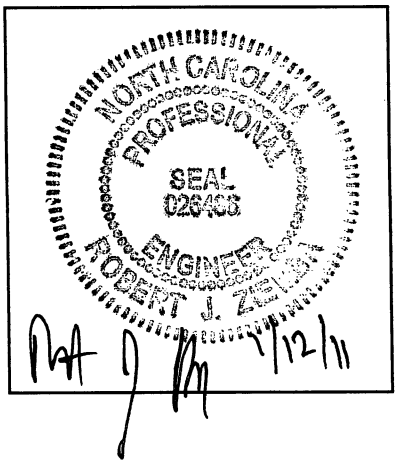


U-2826B

Project Special Provisions
(Version 06.7)
Signals and Intelligent Transportation Systems

Prepared By: TST
12-Jan-11

Contents

1. 2006 STANDARD SPECIFICATIONS FOR ROADS & STRUCTURES

The 2006 Standard Specifications are revised as follows:

1.1. General Requirements (1098-1)

Page 10-268, Subarticle 1098-1(H)

In the first paragraph, revise the second sentence to "Ensure service disconnects are listed as meeting UL Standard UL-489 and marked as being suitable for use as service equipment."

In the second paragraph, revise the first sentence to "Furnish NEMA Type 3R meter base rated 100 Ampere minimum that meets the requirements of the local utility. Provide meter base with sockets' ampere rating based on sockets being wired with minimum of 167 degrees F insulated wire."

In the second paragraph, last item on page, revise to "With or without horn bypass."

Page 10-269, Subarticle 1098-1(H)

Revise the second line to "Listed as meeting UL Standard UL-414."

In the first full paragraph on page, remove the first sentence.

Revise the last paragraph to "If meter base and electrical service disconnect are supplied in the same enclosure, ensure assembly is marked as being suitable for use as service equipment. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. Otherwise, ensure combination meter and disconnect is listed as meeting UL Standard UL-67.

Page 10-269, Subarticle 1098-1 (J)

ADD new Subarticle 1098-1 (J) **Performance of Warranty Repair and Maintenance**

Provide authorization to the Traffic Electronics Center of the North Carolina Department of Transportation (NCDOT) to perform all warranty repairs after project acceptance. The decision to perform warranty work at the Traffic Electronics Center by NCDOT electronics technicians or to have warranty work performed by the vendor shall be at the discretion of the State. Provide any training required by the manufacturer to authorize the Traffic Electronics Center to perform warranty work and ensure manufacturer will furnish parts to the Traffic Electronics Center for all warranty repairs at no cost to the State. In addition, ensure the manufacturer agrees to provide prompt technical support to the NCDOT electronics technicians for a period of one year after the end of the warranty period at no cost to the State. Defective parts replaced under warranty by the Traffic Electronics Center will be returned to the vendor at the vendor's request. Provide schematics, part lists, and other documentation to perform bench repair to the Traffic Electronics Center within two weeks upon request. The Department agrees not to divulge any proprietary information in the schematics, part lists, and other documentation upon request from the vendor. After project acceptance and at the request of the State, manufacturer shall perform warranty repairs to equipment which fails during the warranty period at no cost to the State including freight costs to ship repaired equipment back to the Traffic Electronics Center. Ensure all equipment is repaired and returned to the Traffic Electronics Center within twenty-one calendar days of receipt by the manufacturer.

Page 10-269, Subarticle 1098-1 (K)

ADD new Subarticle 1098-1 (K) **Maintenance and Repair of Materials**

Perform maintenance (testing) on all Traffic Signal Conflict Monitors every twelve (12) months for the life of the project beginning with the initial test and every twelve (12) months thereafter. Provide the initial test date via the manufacturer's certification or via testing prior to installation of

the conflict monitor at an intersection. Use the ATSI Incorporated Model PCMT-2600 Conflict Monitor Tester, or an Engineer approved equivalent. Ensure that the Conflict Monitor Tester is maintained and calibrated per the manufacturer's recommendation. Provide to the Engineer a copy of the manufacturer's certification that the Conflict Monitor Tester is in proper working order before testing the Traffic Signal Conflict Monitors. Perform the test on the Traffic Signal Conflict Monitors per the manufacturer's recommendation. For each Traffic Signal Conflict Monitor tested, provide two (2) dated copies of the test results: one (1) copy for the Engineer and one (1) copy for the traffic signal cabinet.

1.2. Wood Poles (1098-6)

Page 10-272, Delete article. Refer to Subarticles 1082 –3(F) and 1082-4(G).

1.3. Loop Lead-in Cable (1098-8)

Page 10-274, Delete article and replace with the following:

Furnish lead-in cable with two conductors of number 14 AWG fabricated from stranded tinned copper that complies with IMSA Specification 50-2 except as follows:

Ensure conductor is twisted with a maximum lay of 2.0 inches, resulting in a minimum of 6 turns per foot.

Provide a ripcord to allow cable jacket to be opened without using a cutter.

Provide length markings in a contrasting color showing sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10 inch.

1.4. Pedestals (1098-13)

Page 10-279, Subarticle 1098-13, Replace the last paragraph with the following:

For each pedestal, provide four anchor bolts in accordance with ASTM F 1554 Grade 55 with outside diameter of 3/4" and length of 18" each having two heavy hex nuts with two washers at the top and two heavy hex nuts with one washer at the bottom. Provide anchor bolts with coarse threads at 10 threads per inch for a minimum length of 4 inches from each end of the bolt. Ensure anchor bolts are hot-dipped galvanized in accordance with ASTM A 153 with completely galvanized nuts and washers. Provide hex nuts with coarse threads. Ensure hex nuts are in accordance with ASTM A 563 Grade DH, ASTM A 194 Grade 2H, or equivalent. Ensure washers are in accordance with ASTM F 436 or equivalent. As a minimum, provide standard size washers.

1.5. Underground Conduit – Construction Methods (1715-3)

Page 17-10, Subarticle 1715-3(B) Section (1), Revise 1st paragraph, 2nd sentence to:

Install rigid metallic conduit for all underground runs located inside railroad right-of-way.

1.6. Junction Boxes – Construction Methods (1716-3)

Page 17-15, Subarticle 1716-3, add the following information at the end of the subarticle:

Provide real world coordinates for all junction boxes and equipment cabinets installed or utilized under this project. Provide the coordinates in feet units using the North Carolina State Plane coordinate system (1983 North American Datum also known as NAD '83). Furnish coordinates that do not deviate more than 1.7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer.

Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, and NCDOT inventory number) in the Microsoft spreadsheet provided by the Department, shown by example below.

NCDOT Inv #	Name	Location	Latitude	Longitude	Manufacturer	Model #
05-0134	Equipment Cabinet	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5500	35.6873	McCain	Type-332
05-0134	Junction Box # 1 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 2 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
5-0134	Junction Box # 3 (Near Cabinet)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 4 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 5 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 6 (Phase 4 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

1.7. Riser Assemblies – Construction Methods (1722-3)

Page 17-18, Subarticle 1722-3, Add the following:

Transition from the rigid galvanized steel risers to underground PVC conduits using an approved rigid galvanized steel sweeping elbow with PVC female adaptor.

1.8. Inductive Detection Loops – Construction Methods (1725-3)

Page 17-20, Subarticle 1725-3, In the first paragraph, revise the first sentence to:

"Between where loop conductor pairs leave saw cut in pavement and junction boxes, twist loop conductor pairs a minimum of 5 turns per foot."

1.9. Loop Lead-in Cable – Measurement and Payment (1726-4)

Page 17-20, Delete first paragraph and replace with the following:

Lead-in cable will be measured and paid as the actual linear feet of lead-in cable furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all cables before determining length of cable run.

2. ELECTRICAL REQUIREMENTS

Ensure that an IMSA certified, or equivalent, Level II traffic qualified signal technician is standing by to provide emergency maintenance services whenever work is being performed on traffic signal controller cabinets and traffic signal controller cabinet foundations. Stand by status is defined as being able to arrive, fully equipped, at the work site within 30 minutes ready to provide maintenance services.

3. SIGNAL HEADS

3.1. MATERIALS

A. General:

Fabricate vehicle signal head housings and end caps from die-cast aluminum. Fabricate 16-inch pedestrian signal head housings and end caps from die-cast aluminum. Provide visor mounting screws, door latches, and hinge pins fabricated from stainless steel. Provide interior screws, fasteners, and metal parts fabricated from stainless steel or corrosion resistant material.

Fabricate tunnel and traditional visors from sheet aluminum.

Paint all surfaces inside and outside of signal housings and doors. Paint outside surfaces of tunnel and traditional visors, messenger cable mounting assemblies, pole and pedestal mounting assemblies, and pedestrian pushbutton housings. Have electrostatically-applied, fused-polyester paint in highway yellow (Federal Standard 595C, Color Chip Number 13538) a minimum of 2.5 to 3.5 mils thick. Do not apply paint to the latching hardware or rigid vehicle signal head mounting brackets for mast-arm attachments.

Have the interior surfaces of tunnel and traditional visors painted an alkyd urea black synthetic baking enamel with a minimum gloss reflectance and meeting the requirements of MIL-E-10169, "Enamel Heat Resisting, Instrument Black."

For pole mounting, provide side of pole mounting assemblies with framework and all other hardware necessary to make complete, watertight connections of the signal heads to the poles and pedestals. Fabricate the mounting assemblies and frames from aluminum with all necessary hardware, screws, washers, etc. to be stainless steel. Provide mounting fittings that match the positive locking device on the signal head with the serrations integrally cast into the brackets. Provide upper and lower pole plates that have a 1 ¼-inch vertical conduit entrance hubs with the hubs capped on the lower plate and 1 ½-inch horizontal hubs. Ensure that the assemblies provide rigid attachments to poles and pedestals so as to allow no twisting or swaying of the signal heads. Ensure that all raceways are free of sharp edges and protrusions, and can accommodate a minimum of ten Number 14 AWG conductors.

For pedestal mounting, provide a post-top slipfitter mounting assembly that matches the positive locking device on the signal head with serrations integrally cast into the slipfitter. Provide stainless steel hardware, screws, washers, etc. Provide a minimum of six 3/8 X 3/4-inch long square head bolts for attachment to pedestal. Provide a center post for multi-way slipfitters.

For light emitting diode (LED) traffic signal modules, provide the following requirements for inclusion on the Department's Qualified Products List for traffic signal equipment.

1. Sample submittal,
2. Third-party independent laboratory testing results for each submitted module with evidence of testing and conformance with all of the Design Qualification Testing specified in section 6.4 of each of the following Institute of Transportation Engineers (ITE) specifications:
   - Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement
   - Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement
   - Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules.

(Note: The Department currently recognizes two approved independent testing laboratories. They are Intertek ETL Semko and Light Metrics, Incorporated with Garwood Laboratories. Independent laboratory tests from other laboratories may be considered as part of the QPL submittal at the discretion of the Department,

3. Evidence of conformance with the requirements of these specifications,
4. A manufacturer's warranty statement in accordance with the required warranty, and
5. Submittal of manufacturer's design and production documentation for the model, including but not limited to, electrical schematics, electronic component values, proprietary part numbers, bill of materials, and production electrical and photometric test parameters.
6. Evidence of approval of the product to bear the Intertek ETL Verified product label for LED traffic signal modules.

In addition to meeting the performance requirements for the minimum period of 60 months, provide a written warranty against defects in materials and workmanship for the modules for a period of 60 months after installation of the modules. During the warranty period, the manufacturer must provide new replacement modules within 45 days of receipt of modules that have failed at no cost to the State. Repaired or refurbished modules may not be used to fulfill the manufacturer's warranty obligations. Provide manufacturer's warranty documentation to the Department during evaluation of product for inclusion on Qualified Products List (QPL).

B. Vehicle Signal Heads:

Comply with the ITE standard "Vehicle Traffic Control Signal Heads". Provide housings with provisions for attaching backplates.

Provide visors that are 10 inches in length for 12-inch vehicle signal heads.

Provide a termination block with one empty terminal for field wiring for each indication plus one empty terminal for the neutral conductor. Have all signal sections wired to the termination block. Provide barriers between the terminals that have terminal screws with a minimum Number 8 thread size and that will accommodate and secure spade lugs sized for a Number 10 terminal screw.

Mount termination blocks in the yellow signal head sections on all in-line vehicle signal heads. Mount the termination block in the red section on five-section vehicle signal heads.

Furnish vehicle signal head interconnecting brackets. Provide one-piece aluminum brackets less than 4.5 inches in height and with no threaded pipe connections. Provide hand holes on the bottom of the brackets to aid in installing wires to the signal heads. Lower brackets that carry no wires and are used only for connecting the bottom signal sections together may be flat in construction.

For messenger cable mounting, provide messenger cable hangers, wire outlet bodies, balance adjusters, bottom caps, wire entrance fitting brackets, and all other hardware necessary to make complete, watertight connections of the vehicle signal heads to the messenger cable. Fabricate mounting assemblies from malleable iron or steel and provide serrated rings made of aluminum. Provide messenger cable hangers and balance adjusters that are galvanized before being painted. Fabricate balance adjuster eyebolt and eyebolt nut from stainless steel or galvanized malleable iron. Provide messenger cable hangers with U-bolt clamps. Fabricate washers, screws, bolts, clevis pins, cotter pins, nuts, and U-bolt clamps from stainless steel.

Provide LED vehicular traffic signal modules (hereafter referred to as modules) that consist of an assembly that uses LEDs as the light source in lieu of an incandescent lamp for use in traffic signal sections. Use LEDs that are aluminum indium gallium phosphorus (AlInGaP) technology for red and yellow indications and indium gallium nitride (InGaN) for green indications. Install the ultra bright type LEDs that are rated for 100,000 hours of continuous operation from -40°F to +165°F. Design

modules to have a minimum useful life of 60 months and to meet all parameters of this specification during this period of useful life.

For the modules, provide spade terminals crimped to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard signal head. Do not provide other types of crimped terminals with a spade adapter.

Ensure the power supply is integral to the module assembly. On the back of the module, permanently mark the date of manufacture (month & year) or some other method of identifying date of manufacture.

Tint the red, yellow and green lenses to correspond with the wavelength (chromaticity) of the LED. Transparent tinting films are unacceptable. Provide a lens that is integral to the unit with a smooth outer surface.

1. LED Circular Signal Modules:

Provide modules in the following configurations: 12-inch circular sections. All makes and models of LED modules purchased for use on the State Highway System shall appear on the current NCDOT Traffic Signal Qualified Products List (QPL).

Provide the manufacturer's model number and the product number (assigned by the Department) for each module that appears on the 2006 or most recent Qualified Products List. In addition, provide manufacturer's certification in accordance with Article 106-3 of the *Standard Specifications,* that each module meets or exceeds the ITE "Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement" dated June 27, 2005 (hereafter referred to as VTCSH Circular Supplement) and other requirements stated in this specification.

Provide modules that meet the following requirements when tested under the procedures outlined in the VTCSH Circular Supplement:

Module Type	Max. Wattage at 165° F	Nominal Wattage at 77° F
12-inch red circular	17	11
12-inch green circular	15	15

For yellow circular signal modules, provide modules tested under the procedures outlined in the VTCSH Circular Supplement to insure power required at 77° F is 22 Watts or less for the 12-inch circular module.

Note: Use a wattmeter having an accuracy of ±1% to measure the nominal wattage and maximum wattage of a circular traffic signal module. Power may also be derived from voltage, current and power factor measurements.

2. LED Arrow Signal Modules

Provide 12-inch omnidirectional arrow signal modules. All makes and models of LED modules purchased for use on the State Highway System shall appear on the current NCDOT Traffic Signal Qualified Products List (QPL).

Provide the manufacturer's model number and the product number (assigned by the Department) for each module that appears on the 2006 or most recent Qualified Products List. In addition, provide manufacturer's certification in accordance with Article 106-3 of the *Standard Specifications,* that each module meets or exceeds the requirements for 12-inch omnidirectional modules specified in the ITE "Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement" dated July 1, 2007 (hereafter referred to as VTCSH Arrow Supplement) and other requirements stated in this specification.

Provide modules that meet the following requirements when tested under the procedures outlined in the VTCSH Arrow Supplement:

Module Type	Max. Wattage at 165° F	Nominal Wattage at 77° F
12-inch red arrow	12	9
12-inch green arrow	11	11

For yellow arrow signal modules, provide modules tested under the procedures outlined in the VTCSH Arrow Supplement to insure power required at 77° F is 12 Watts or less.

Note: Use a wattmeter having an accuracy of ±1% to measure the nominal wattage and maximum wattage of an arrow traffic signal module. Power may also be derived from voltage, current and power factor measurements.

C. Pedestrian Signal Heads:

Provide pedestrian signal heads with international symbols that meet the MUTCD. Do not provide letter indications.

Comply with the ITE standard for "Pedestrian Traffic Control Signal Indications" and the following sections of the ITE standard for "Vehicle Traffic Control Signal Heads" in effect on the date of advertisement:

- Section 3.00 - "Physical and Mechanical Requirements"
- Section 4.01 - "Housing, Door, and Visor: General"
- Section 4.04 - "Housing, Door, and Visor: Materials and Fabrication"
- Section 7.00 - "Exterior Finish"

Provide a double-row termination block with three empty terminals and number 10 screws for field wiring. Provide barriers between the terminals that accommodate a spade lug sized for number 10 terminal screws. Mount the termination block in the hand section. Wire all signal sections to the terminal block.

Where required by the plans, provide 16-inch pedestrian signal heads with traditional three-sided, rectangular visors, 6 inches long.

Design the LED pedestrian traffic signal modules (hereafter referred to as modules) for installation into standard pedestrian traffic signal sections that do not contain the incandescent signal section reflector, lens, eggcrate visor, gasket, or socket. Provide modules that consist of an assembly that uses LEDs as the light source in lieu of an incandescent lamp. Use LEDs that are of the latest aluminum indium gallium phosphorus (AlInGaP) technology for the Portland Orange hand and countdown displays. Use LEDs that are of the latest indium gallium nitride (InGaN) technology for the Lunar White walking man displays. Install the ultra bright type LEDs that are rated for 100,000 hours of continuous operation from -40°F to +165°F. Design modules to have a minimum useful life of 60 months and to meet all parameters of this specification during this period of useful life.

Provide modules in the following configuration: 16-inch displays which have the solid hand/walking man overlay on the left and the countdown on the right. All makes and models of LED modules purchased for use on the State Highway System shall appear on the current NCDOT Traffic Signal Qualified Products List (QPL).

Provide the manufacturer's model number and the product number (assigned by the Department) for each module that appears on the 2006 or most recent Qualified Products List. In addition, provide manufacturer's certification in accordance with Article 106-3 of the *Standard Specifications,* that each module meets or exceeds the ITE "Pedestrian Traffic Control Signal Indications – Part 2: Light

Emitting Diode (LED) Pedestrian Traffic Signal Modules" dated March 19, 2004 (hereafter referred to as PTCSI Pedestrian Standard) and other requirements stated in this specification.

Design all modules to operate using a standard 3 - wire field installation. Provide spade terminals crimped to the lead wires and sized for a #10 screw connection to the existing terminal block in a standard pedestrian signal housing. Do not provide other types of crimped terminals with a spade adapter.

Ensure the power supply is integral to the module assembly. On the back of the module, permanently mark the date of manufacture (month & year) or some other method of identifying date of manufacture.

Provide module lens that is hard coated or otherwise made to comply with the material exposure and weathering effects requirements of the Society of Automotive Engineers (SAE) J576. Ensure all exposed components of the module are suitable for prolonged exposure to the environment, without appreciable degradation that would interfere with function or appearance.

Design the walking man and hand as a solid display. Ensure the hand/walking man symbols for the 16-inch display module meet the dimension requirements cited in PTCSI Pedestrian Standard Table 1 *"Dimensions of Signal Sizes"* for Class 3 or Class 4.

Provide the countdown number display that is at least 9 inches high by 6 inches wide. Ensure the minimum luminance value for the countdown number display is 1,400 cd/m^2. Provide the countdown number display that will conform to the chromaticity requirements of the hand symbol as specified by section 4.2 (Chromaticity) of the PTCSI Pedestrian Standard. Furnish the countdown display to continuously monitor the traffic controller to automatically learn the pedestrian phase time and update for subsequent changes to the pedestrian phase time. Design the countdown display as a double row of LEDs or with a minimum thickness of 0.5 inch. Ensure the countdown display blanks-out during the initial cycle while it records the countdown time. Ensure that the countdown display is operational only during the flashing don't walk, clearance interval. Blank-out the countdown indication after it reaches zero and until the beginning of the next flashing don't walk indication. Design the controlling circuitry to prevent the timer from being triggered during the solid hand indication. Ensure the countdown display discontinues and goes dark immediately upon activation of a preemption transition. Ensure the countdown display begins normal operation upon the completion of the preemption sequence and no more than one pedestrian clearance cycle.

Provide modules that meet the following requirements when tested under the procedures outlined in the PTCSI Pedestrian Standard:

Module Type	Max. Wattage at 165° F	Nominal Wattage at 77° F
Hand Indication	16	13
Walking Man Indication	12	9
Countdown Indication	16	13

Note: Use a wattmeter having an accuracy of ±1% to measure the nominal wattage and maximum wattage of a pedestrian signal module. Power may also be derived from voltage, current and power factor measurements.

Provide 2-inch diameter pedestrian push-buttons with weather-tight housings fabricated from die-cast aluminum and threading in compliance with the NEC for rigid metal conduit. Provide a weep hole in the housing bottom and ensure that the unit is vandal resistant.

Provide push-button housings that are suitable for mounting on flat or curved surfaces and that will accept 1/2-inch conduit installed in the top. Provide units that have a heavy duty push-button

assembly with a sturdy, momentary, normally-open switch. Have contacts that are electrically insulated from the housing and push-button. Ensure that the push-buttons are rated for a minimum of 5 mA at 24 volts DC and 250 mA at 12 volts AC.

Provide standard R10-3 signs with mounting hardware that comply with the MUTCD in effect on the date of advertisement. Provide R10-3E signs for countdown pedestrian heads and R10-3B for non-countdown pedestrian heads.

D. Signal Cable:

Furnish 16-4 and 16-7 signal cable that complies with IMSA specification 20-1 except provide the following conductor insulation colors:

- For 16-4 cable: white, yellow, red, and green
- For 16-7 cable: white, yellow, red, green, yellow with black stripe tracer, red with black stripe tracer, and green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.

Provide a ripcord to allow the cable jacket to be opened without using a cutter. IMSA specification 19-1 will not be acceptable. Provide a cable jacket labeled with the IMSA specification number and provide conductors constructed of stranded copper.

3.2. CONSTRUCTION METHODS

A. Modify Existing Vehicle Signal Heads:

Modify existing vehicle signal heads by bagging or unbagging and connecting or disconnecting as indicated on the plans for the various phases of construction.

3.3. MEASUREMENT AND PAYMENT

Actual number of existing vehicle signal heads modified and accepted.

Payment will be made under:

Modify Existing Vehicle Signal Head ..... Each

4. TWISTED-PAIR COMMUNICATIONS CABLE

4.1. DESCRIPTION

Furnish and install twisted-pair communications cable with all necessary hardware in accordance with the plans and specifications.

All communications cable is to be fully compatible with the Winston-Salem signal system

4.2. MATERIALS

A. General:

Furnish communications cable with all other tools, materials, and hardware required for successful completion of the work, including but not limited to communications cable identification markers (cable wraps), couplings, connectors, machine bolts, eye bolts, strandvises, cable suspension clamps, and pole bands.

B. Communications Cable:

Furnish the following:

- RUS CFR 1755.390 25-pair, 22-gauge, shielded, twisted-pair communications cable (underground)

Have the manufacturer factory test the communications cable on reels for each pair's mutual capacitance, crosstalk loss, insulation resistance, and conductor resistance. Furnish the Engineer with a certified report for each reel showing compliance with the IMSA or RUS specification, the factory test results, and the manufactured date of the cable. Do not use communications cable manufactured more than one year before the date of installation.

Provide sequential foot markings within one percent of the actual cable length and as required by Section 350G of the National Electrical Safety Code. Provide approximately 1/10-inch character height of the markings.

4.3. CONSTRUCTION METHODS

A. General:

Install communications cable on traffic signal and utility poles, and in conduits to bring the cable into and, if necessary, out of each controller cabinet.

Take all precautions necessary to ensure the communications cable is not damaged during storage and installation. Do not step on the cable nor run over the cable with vehicles or equipment. Do not pull the cable over or around obstructions, or along the ground.

Immediately cease work and notify the Engineer and the affected owner should damage to existing cables or equipment occur. Make the required repairs at no additional cost to the Department.

Provide the Engineer with three copies of the communications cable manufacturer's recommended and maximum pulling tension for each communications cable size before the installation of communications cable.

Install communications cable in continuous lengths from one signalized intersection to the next with no splices outside the cabinet.

Keep the communications cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use a silicone impregnated heat shrink cable end cap approved by the Engineer. Do not use tape to seal the cable ends.

Notify the Engineer in writing a minimum of ten days before beginning communications cable testing.

Test the integrity of the communications cable before installation based on IMSA 20-4, 22-gauge wire standard.

Test the cable insulation for a resistance of more than 500 megaohms for each insulated conductor when measured with all other insulated conductors and the shielded ground before installation. Make the measurement with a DC potential of at least 100 volts but not more than 550 volts applied for 1 minute. Furnish the test results to the Engineer.

Wire communications cable into the cabinet. Allow a minimum of 10 feet of slack for communications cable that is not immediately terminated.

B. Aerial Installation:

Use pole attachment hardware and roller guides with safety clips to install the aerial communications cable.

Maintain tension during the pulling process for aerial run communications cable by using a mechanical clutch (dynamometer) device approved by the Engineer. Do not exceed 80 percent of the manufacturer's maximum allowable pulling tension. Do not allow the communications cable to

contact the ground or other obstructions between the poles during installation. Do not use a motorized vehicle to generate cable-pulling forces.

- **On Messenger Cable**

Double lash the communications cable to the messenger cable where the messenger cable is used solely to support the communications cable.

Wrap the communications cable to the messenger cable using aluminum ribbon wraps where the messenger cable supports other cables (i.e., traffic signal cable, lead-in cable, etc.).

- **With Integral Messenger Cable**

Use 5/8-inch diameter machine bolts to attach suspension clamps to the wood poles for attaching integral messenger cable. Provide machine bolts with washers and square nuts that are 3 inches longer than the pole diameter.

Use 5/8-inch diameter eyebolts with washers and nuts (or eyenuts if required) to attach strandvises to the wood poles at controller cabinets and poles where messenger cable is terminated into a strandvise. Secure the messenger cable to the strandvises with an eyebolt or nut so that the messenger cable will not pull out unless intentionally released. Install the cable suspension clamps directly to the jacketed messenger cable without crushing into the cable core jacket. Do not split or strip the jacket for attachment to the cable suspension clamp. Use pole bands to make acute turns at poles that cannot accommodate separate eyebolts. Use a cable suspension clamp when attaching communications cable tangent to the pole.

Strip the messenger cable from the integral communications cable that is installed in risers and controller cabinets or is lashed to existing cables. Use a figure-8 cable splitter specifically designed for splitting the communications cable at the web between the messenger cable and the conductors for removing the messenger cable. Replace the entire segment of communications cable at no additional cost to the Department if the communications cable, shield, conductors, or messenger cable are damaged. Do not splice the cable or repair the insulation. Install two cable-lashing straps at the end of each split to prevent further splitting of the figure-8 web.

C. Underground Installation:

Install underground communications cable in 2-inch HDPE and/or PVC conduit using cable-pulling lubricants approved by the communications cable manufacturer and the Engineer. Obtain the Engineer's approval of the cable lubricant and method of pulling before the installation of underground communications cable.

Do not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground communications cable.

Use a clutch device (dynamometer) so as not to exceed the allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable-pulling forces.

Keep tension on the cable reel and the pulling line at the start of each pull. Do not release the tension in the cable if the pulling operation is halted. Restart the pulling operation by gradually increasing the tension until the cable is in motion.

Set cable reels up on the same side of the junction box as the conduit section in which the cable is to be installed. Place the reel level and align the reel with the conduit section such that the cable will pass from the top of the reel in a smooth bend into the conduit without twisting. Do not pull the cable from the bottom of the reel. Manually feed the cable by rotating the reel. Do not pull the cable through intermediate junction boxes, pull boxes, handholes, or openings in conduit unless otherwise approved by the Engineer.

D. Bonding and Splicing:

Terminate all cable pairs in a neatly arranged manner. Use binding-type screw terminal strips of sufficient size to terminate all cable pairs. Clean the terminals before terminating the cable. Apply non-insulated, Number 18-20, spade crimp terminals to the cable using a calibrated ratchet type crimp tool. Solder the terminals and coat the binding-type screw terminal strips and connections with a corrosive-prevention material after crimping.

Splice communications cable within the controller cabinets and splice cabinets. Do not splice within pull boxes.

Ground the shield of the outgoing cable (going away from the master controller) to a ground rod using insulated (green) number 14 AWG standard copper wire at all controller cabinet locations. Leave the shield of the incoming cable ungrounded. Bond and ground the cable shields as required by RUS CFR 1755.200.

4.4. MEASUREMENT AND PAYMENT

Actual linear feet of twisted-pair communications cable furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on the outer jacket of the twisted-pair communications cable from the start of the cable run to the end of the cable run for each cable run. All pairs shall be terminated before determining the length of cable run.

No measurement will be made of communications cable identification markers as these will be considered incidental to furnishing and installing communications cable.

Payment will be made under:

Communications Cable (25-Twisted-pair)..... Linear Foot

5. RELOCATE EXISTING SIGN

5.1. DESCRIPTION

Relocate existing signs.

5.2. CONSTRUCTION METHODS

As directed by the plans, relocate existing signs. Comply with Article 1745-3 Signs Installed for Signals.

5.3. MEASUREMENT AND PAYMENT

Actual number of existing signs, regardless of mounting method, relocated and accepted.

Payment will be made under:

Relocate Existing Sign.....Each

6. CONTROLLERS WITH CABINETS

6.1. MATERIALS – NEMA TS-2 TYPE 2 CONTROLLERS

Furnish NEMA TS-2, Type 2 ASC/3, or approved equivalent. Include a NEMA standard overlap card.

Ensure that all components are arranged for easy access during servicing. When modular in construction, provide guides and positive connection devices to insure proper pin alignment and connection.

Provide a moisture resistant coating on all circuit boards.

All controllers, including telemetry panels and telemetry cards, are to be fully compatible with the Winston-Salem signal system

6.2. MATERIALS – GENERAL CABINETS

All cabinets, including telemetry panels and telemetry cards, are to be fully compatible with the Winston-Salem signal system

Provide a moisture resistant coating on all circuit boards.

Provide one V150LA20 MOV or equal protection on each load switch field terminal.

Provide a power line surge protector that is a two-stage device that will allow connection of the radio frequency interference filter between the stages of the device. Ensure that a maximum continuous current is at least 10A at 120V. Ensure that the device can withstand a minimum of 20 peak surge current occurrences at 20,000A for an 8x20 microsecond waveform. Provide a maximum clamp voltage of 280V at 20,000A with a nominal series inductance of 200µh. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

6.3. MATERIALS – NEMA TS-2 TYPE 1 CABINETS

A. NEMA TS-2 Type 1 Cabinets General:

Comply with the *NEMA Standards Publication TS-2* (NEMA TS-2) except as otherwise stated herein.

All cabinets, including telemetry panels and telemetry cards, are to be fully compatible with the Winston-Salem signal system

Furnish unpainted, natural, aluminum cabinet shells that comply with Section 7 of NEMA TS-2. Ensure all non-aluminum hardware on the cabinet is stainless steel or a Department approved non-corrosive alternate. Provide a roof with a slope from front to back at a minimum ratio of 1 inch drop per 2 feet. Ensure that each exterior cabinet plane surface is constructed of a single sheet of aluminum and is seamless.

Ensure all components are arranged for easy access during servicing. When modular in construction, provide guides and positive connection devices to insure proper pin alignment and connection.

Provide a moisture resistant coating on all circuit boards.

B. NEMA TS-2 Type 1 Cabinet Physical Requirements:

Provide a handle and three point latching mechanism designed to be disassembled using hand tools. Provide a shaft connecting the latching plate to the door handle by passing through the door within a bushing, bearing, or equivalent device. Provide a latching plate at least 3/16 inch thick and

that mates securely with the lock bolt. Provide a lock bolt with a flat end (no bevel) and that has at least 1/4 inch of length in contact with the latching plate.

Ensure that the handle and lock are positioned so that the lock does not lie in the path of the rotating handle as the door is unlatched and that the handle points down in the latched position.

Provide continuous welds made from the inside wherever possible. On the exterior, provide smooth and flush joints. Ensure that no screws, bolts, or rivets protrude to outside of cabinet shell.

Provide a main door opening that encompasses the full frontal area of the cabinet shell exclusive of the area reserved for plenums and flanges. Provide a rear door in base-mounted cabinets, unless otherwise specified. Ensure that the rear door complies with all requirements for the front door, except as follows:

- Hinge the rear door on the left side as viewed from the rear of the cabinet shell facing the door.
- No police compartment is required on a rear door.

Ensure that the cabinet shell is sturdy and does not exhibit noticeable flexing, bending or distortion under normal conditions except that a minor amount of flexing is permitted in the main door and rear door only when the cabinet is open. In such case, the flexing must not result in permanent deformation of the door or damage to components mounted on the door. Ensure that pedestal-mounted cabinets have sufficient framing around the slipfitter attachment so that no noticeable flexing will occur at or about this point.

Provide NEMA TS-2, Type 1 cabinets with 2 shelves. Ensure top shelf has an unobstructed depth of at least 12 inches for base-mounted cabinets. Ensure top shelf has an unobstructed shelf depth of at least 13 inches for pole-mounted cabinets. Locate the top shelf at least 12 inches below the top of the door opening. Provide a lower shelf for mounting detector racks, its associated BIU, and other auxiliary equipment. Locate the lower shelf at least 10 inches below the top shelf, and provide at least 13 inches of unobstructed shelf depth. Secure card racks and associated BIU connector housings to the shelf by a removable means. Place the rack so that the front of the rack is not obscured by any object and so that backpanel terminals are not obscured even when the rack is fully utilized.

Provide a back panel hinged at the bottom for access during service.

Provide a minimum 12 x 14 inch plastic envelope or container located in the cabinet so that it is convenient for service personnel.

Furnish two sets of non-fading cabinet wiring diagrams and schematics in a paper envelope or container and placed in the plastic envelope or container.

Do not locate permanently mounted equipment in such a way that will restrict access to terminals.

C. NEMA TS-2 Type 1 Cabinet Electrical Requirements:

Provide a neutral that is not connected to the earth ground or the logic ground anywhere within the cabinet. Ensure the earth ground bus and the neutral ground bus each have ten compression type terminals each of which can accommodate wires ranging from number 14 through number 4.

Provide surge suppression in the cabinet and ensure that all devices operate over the temperature range of -40 to 185 degrees F.

Provide a loop surge suppresser for each set of loop terminals in the cabinet. Use terminal mount or stud mount devices for terminating the loop surge suppresser. Ensure that the device can withstand a minimum of 25 peak surge current occurrences at 100A in differential and common

modes for a 10x700 microsecond waveform. Ensure that the maximum breakover voltage is 170V and the maximum on-state clamping voltage is 30V. Provide a maximum response time less than 5 nanoseconds and an off-state leakage current less than 10 μA. Ensure that a nominal capacitance less than 220pf for both differential and common modes.

Provide surge suppression on each communications line entering or leaving a cabinet. Ensure that the communications surge suppresser can withstand at least 80 occurrences of an 8x20 microsecond waveform at 2000A, or a 10x700 microsecond waveform at 400A. Provide a maximum clamping voltage suited to the equipment protected. Provide a maximum response time less than 1 nanosecond with a nominal capacitance less than 1500pf and a series resistance less than 15 Ω.

Furnish a fluorescent fixture as required by NEMA TS-2 Specifications with a second lighting fixture mounted under the bottom shelf to light the terminals. Ensure that the second fixture is a fluorescent lighting fixture that complies with NEMA TS-2 Specifications or is a flexible gooseneck fixture containing a protected incandescent reflector bulb of at least 25 Watts. Furnish all bulbs. Ensure that the lamps are door switch actuated.

Provide connector type harnesses for all equipment installed in the cabinet, including detector racks. Furnish a harness with connectors to adapt the NEMA TS-2, Type 2 controller "A" connector to the NEMA TS-2, Type 1 "A" connector furnished with the cabinet assembly.

Tag all conductors that are likely to be disconnected from time to time with non-fading, permanent sleeve labels at the ends of the conductors.

In cabinets that are not base mounted, have no terminals closer than 4 inches to the bottom of the cabinet.

Fasten all wiring and harness supports to the cabinet with screws or other removable mechanical means. Do not use adhesives.

Provide harnesses in the cabinet for non-permanently mounted equipment that are long enough to allow the equipment to be relocated in an upright position to the roof of the cabinet or to be located to the ground 1 foot below cabinet level.

Do not locate terminals on the underside of shelves or at other places where they are not readily visible and accessible, or where they may be a hazard to personnel. Provide a clear plastic guard for exposed 120 volt AC terminals on the power panel and the rear of terminal facilities accessible from the rear door.

Provide compression type earth grounds with 10 position terminal buses sized for four Number 14 AWG wires. Provide screw-type terminals for signal feed, detector lead-in, NEMA I/Os, backpanels, and interconnect terminals. Provide screw terminals for all other devices not defined by NEMA TS-2 Specifications. Ensure that wiring by the manufacturer is terminated either on double terminal strips with crimped-on lugs or soldered to rear terminals.

Ensure that upon leaving any cabinet or malfunction management unit (MMU) initiated flashing operation, the controller reverts to its programmed start-up operation through the use of the START UP FLASH CALL feature. Do not require special controller software to implement the return from flash in the start up mode of operation. Wire one of the output relays of the MMU to apply a logic ground to the STOP TIME input for rings 1 and 2 when the MMU initiates flashing operation because of a sensed failure. Ensure that the MMU is interlocked within the cabinet control circuitry as to prevent normal signal operation with the MMU disconnected. Ensure that the 24Vdc supply to the load switches is disconnected when cabinet flashing operation is initialized. Provide a momentary pushbutton, or equivalent method, to apply 24Vdc to the load switches during cabinet flash for troubleshooting purposes.

Unless otherwise required, provide switches that are heavy-duty toggle switches.

Provide a technician panel mounted on the inside of the door with an EQUIPMENT POWER (ON/OFF) switch and an AUTO/FLASH switch. Ensure switches are protected against accidental activation by a flip-up switch guard that does not affect switch position when closed. Provide an EQUIPMENT POWER (ON/OFF) toggle switch that connects or disconnects protected equipment power to all devices in the cabinet and does not affect AC power to the flasher. Provide an AUTO/FLASH toggle switch which immediately places the intersection into flashing operation, disconnects the STOP TIME input generated by the MMU, and applies a logic ground to the LOCAL FLASH STATUS input of the MMU. When placed in the AUTO position, ensure that this switch causes the return of the intersection to normal operation at the programmed start up phases and intervals via the START-UP FLASH CALL feature of the controller unit. Provide a DETECTOR CHANNEL CALL three position detector test switch (on, normal, momentary on) installed for every detector channel in the detector racks. Provide four pedestrian detector test switches (on normal, momentary on) to the 4 pedestrian detector inputs of BIU no. 1. The switches may be installed on the door or on the non-door hinge side of the cabinet at the front of the cabinet.

Provide a police compartment constructed such that neither water nor dust will enter the interior of the cabinet through the police compartment, even when the police compartment door is open. Provide a rigid enclosure over the terminals of its components. Do not use flexible guards. Provide a SIGNAL POWER (ON/OFF) switch, an AUTO/FLASH switch, and an AUTO/MANUAL switch. Provide a locking jack for an optional manual push-button. Provide a SIGNAL POWER (ON/OFF) toggle switch which, when in the "OFF" position, disconnects AC power to the field terminals, applies logic ground to the LOCAL FLASH STATUS input of the MMU, and disconnects the STOP TIME input generated by the MMU. Ensure that a means to prevent recognition of red failure by the malfunction management unit is used and the switch does not affect power to equipment in the cabinet. When the SIGNAL POWER switch is switched to the "ON" position, ensure controller reverts to the programmed start-up phases and intervals via the START-UP FLASH CALL feature of the controller unit. Provide an AUTO/FLASH toggle switch that immediately places the intersection into flashing operation, and applies logic ground to the MMU LOCAL FLASH STATUS input. When placed in the AUTO position, ensure this switch allows the return of the intersection to normal operation at the programmed start-up phases and intervals via THE START-UP FLASH CALL feature of the controller unit. Provide an AUTO/MANUAL toggle switch that selects between normal operation (in the AUTO position) and manually controlled operation (in the MANUAL position). When in the MANUAL position, ensure that a logic ground is applied to the Manual Control Enable input of the controller. Ensure that only when a logic ground signal is applied to Manual Control Enable, the optional manual push-button can be used to advance the phases by applying and removing a logic ground signal to the Interval Advance input.

Provide one flash transfer relay and flasher for each corresponding socket. Provide 2 spare terminals for each flasher circuit output. Provide 1 MMU and 1 cabinet DC power supply (shelf mounted) with all necessary harnesses wired to the appropriate cabinet/back panel termination points. Terminate unused MMU inputs. Provide BIUs with sockets and terminal facilities. BIUs 3 and 4 may be mounted in a rack separate from the back panel.

Provide a minimum of 2 sets of loop terminals and a single earth ground terminal between the 2 sets of loop wire terminals for each slot in each detector rack provided.

In cabinets with less than 16 loadbay positions, provide flash transfer relay circuits for load switches used to implement pedestrian signals that are brought out to separate terminals but not connected for flashing operation when pedestrian signals are assigned to the load switch channel.

Ensure that the flash circuit inputs and outputs are available for easy connection to allow conversion of a pedestrian movement load switch for use as an overlap (vehicle phase) movement load switch. Provide a reserved flash transfer relay circuit for four vehicle movements and all necessary flash transfer relay input and output wiring and flash circuit wiring that can be made available at each pedestrian load switch position.

Comply with the applicable tables for the type of cabinet furnished:

TS-2 Type 1 Cabinet Configurations

CABINET CONFIGURATION	LOAD SWITCH SOCKETS	FLASH RELAY SOCKETS	FLASHER SOCKETS	BIU'S REQUIRED (BACK PANEL/ DETECTOR)	DETECTOR RACK TYPE/ QUANTITY	TS-2 CABINET TYPE*
NC-1	4	2	1	1/1	1/1	4**
NC-2	8	4	1	1/1	2/1	5
NC-3	12	6	1	2/1	2/1	6
NC-3A	12	6	1	2/2	2/2	6
NC-3B	12	6	1	2/2	2/1 1/1	6
NC-4	12	6	1	†3/1	2/1	6
NC-4A	12	6	1	†3/2	2/2	6
NC-4B	12	6	1	†3/2	2/1 1/1	6
NC-5	12	6	1	‡4/1	2/1	6
NC-5A	12	6	1	‡4/2	2/2	6
NC-5B	12	6	1	‡4/2	2/1 1/1	6
NC-6	16	6	1	2/2	2/2	6
NC-6A	16	6	1	2/2	2/1 1/1	6
NC-7	16	6	1	†3/2	2/2	6
NC-7A	16	6	1	†3/2	2/1 1/1	6
NC-8	16.	6	1	‡4/2	2/2	6
NC-8A	16	6	1	‡4/2	2/1 1/1	6

*See NEMA TS-2-1998, Table 7-1 for actual dimensions.

**Type 5 cabinet may be substituted for four position base mount cabinet.

† BIU 3 required along with BIU 1, BIU 2, and detector BIU(s).

‡ BIU 3 and BIU 4 required along with BIU 1, BIU 2, and detector BIU(s).

8-Position Loadbay Cabinet Phase Assignments

PHASE /OL NUMBER	MALFUNCTION MANAGEMENT UNIT CHANNEL ASSIGNMENT	ASSIGNED TO LOAD SWITCH POSITION NUMBER	ASSIGNED TO FLASH RELAY NUMBER	ASSIGNED TO FLASHER CIRCUIT/	PROGRAM FLASH COLOR
1	1	1	1	1	R
2	2	2	1	2	Y
3	3	3	2	1	R
4	4	4	2	2	R
2 PED-O/LA †	5	5	†3	†1	D
4 PED O/L .B†	6	6	†3	†2	D
O/L C	7	7	4	1	R
O/L D	8	8	4	2	R

† Prepare this load switch position for the pedestrian movement indicated. Wire pedestrian signals to flash dark. Make flash circuitry for this load switch position available and accessible at a separate terminal to allow connection to the load switch and field terminal circuit for a vehicle movement at a later date if desired.

12-Position Loadbay Cabinet Phase Assignments

PHASE /OL NUMBER	MALFUNCTION MANAGEMENT UNIT CHANNEL ASSIGNMENT	ASSIGNED TO LOAD SWITCH POSITION NUMBER	ASSIGNED TO FLASH RELAY NUMBER	ASSIGNED TO FLASHER CIRCUIT/	PROGRAM FLASH COLOR
1	1	1	1	1	R
2	2	2	1	2	Y
3	3	3	2	1	R
4	4	4	2	2	R
5	5	5	3	2	R
6	6	6	3	1	Y
7	7	7	4	2	R
8	8	8	4	1	R
2 PED or O/L A†	9	9	†5	†1	D
4 PED or O/L B†	10	10	†5	†2	D
6 PED or O/C†	11	11	†6	†1	D
8 PED or O/L D†	12	12	†6	†2	D

† Prepare this load switch position for the pedestrian movement indicated. Wire pedestrian signals to flash dark. Make flash circuitry for this load switch position available and accessible at a separate terminal to allow connection to the load switch and field terminal circuit for a vehicle movement at a later date.

Provide flasher circuits and flash transfer relay outputs and inputs that are brought out to terminals which provide a convenient means of changing flash color and flash circuit at each load switch position. Ensure that changing flash color of a given phase or overlap involves no more than moving three wires. Ensure that the selected phase or overlap flash color load switch output is easily movable to connect to the normally open flash transfer relay input assigned to the phase or overlap. Ensure that the common output of the flash transfer relay circuit assigned to the phase or overlap is easily movable to the selected field terminal (input) of the phase or overlap flash color. Ensure that the non-flashed load switch output is easily moved to provide power directly to the phase or overlap field terminal for that color.

In cabinets requiring a Type 1 detector rack, route to and terminate on a conveniently located terminal block on the back panel or elsewhere in the cabinet, the eight unused detector BIU Vehicle Call inputs. Tie the 8 unused detector BIU Detector Status inputs to the logic ground.

Provide detector racks and associated detector rack BIUs that are removable and replaceable from the cabinet either as a complete assembly or separately. Ensure that disconnection and reconnection of these units is through quick disconnect type connectors.

6.4. MATERIALS – NEMA TS-2 DETECTOR CARDS AND RACKS

Furnish NEMA TS-2 multi-channel detector cards and racks.

Provide cards that sequentially scan each of its channels. Provide channels with a minimum of eight sensitivity levels.

On a multi-channel detector, ensure that it is possible to turn a channel off and disable its operation from the front panel.

Ensure that detector units meet the requirements of NEMA TS-2 Specifications except as follows:

- Class 2 vehicle output is maintained for a minimum of 4 minutes, and
- Class 3 vehicle output is maintained for a minimum of 30 minutes, maximum 120 minutes.

Where required, furnish detector cards equipped with required timing features. Provide a delay that is settable in one second increments (maximum) over the range of zero to thirty seconds. Provide an extend that is settable in 1/4 second increments (maximum) over the range of 0 to 15 seconds. Provide cards that can set both delay and extend timing for the same channel. If both timings are set, ensure that the delay operates first. After the delay condition has been satisfied, ensure that the extend timer operates normally and that it is not necessary to satisfy the delay timing for an actuation arriving during the extend portion.

Ensure that two-channel detector cards operate normally with the same loop connected to both channels.

Provide lightning and surge protection that is incorporated into the design of the detector. Ensure that each channel operates properly when used with the loop detector surge protector.

In addition to NEMA TS-2 Specifications, ensure that each channel is capable of tuning to and operating on any loop system inductance within the range of 50 to 2,000 µh. Ensure that the channel will operate properly even on a loop system that has a single-point short to earth ground.

7. REMOVAL OF EXISTING TRAFFIC SIGNAL INSTALLATIONS

7.1. DESCRIPTION

Remove existing traffic signal installations.

7.2. CONSTRUCTION METHODS

A. General:

At the direction of the Engineer, remove existing traffic signal installations at the following locations:

SR 4325 (N. Martin Luther King, Jr. Dr.) at East 4th Street ..... (09-0120)
US 52-311/NC 8 NB Ramp/Metropolitan Drive at East 3rd Street ..... (09-0673)
US 52-311/NC 8 SB Ramp/Maple Ave. at East 3rd Street ..... (09-0672)
Metropolitan Drive at East 4th Street ..... (09-0697)
Maple Ave. at East 4th Street ..... (09-0698)
US 52-311/NC 8 NB Ramp/Metropolitan Drive at East 5th Street ..... (09-0695)
US 52-311/NC 8 SB Ramp/Maple Ave. at East 5th Street ..... (09-0696)

Maintain and repair traffic signal equipment within the limits of the project until the traffic signal equipment is disconnected and stockpiled.

B. Removal:

Dismantle and remove existing traffic signal equipment and material, excluding joint use poles. Disconnect and remove all Department equipment from joint use poles in a manner that will not damage the poles or existing utilities. Cut electrical conduit and remove to at least 18 inches below finished ground elevation unless otherwise directed by the Engineer.

Install the required regulatory signs in accordance with Sections 900, 901, and 903 of the *Standard Specifications* before deactivating the traffic signal installation. Cover the signs with burlap bags until the traffic signal is put into flashing operation.

Place the traffic signal installation into flashing operation and immediately uncover the signs. Operate in flash mode for a minimum of one week.

Deactivate, dismantle, and remove the traffic signal installation after the one-week period unless otherwise directed by the Engineer.

Use methods to remove the traffic signal installation that will not result in damage to other portions of the project or facility. Repair damage that results from the Contractor's actions at no additional cost to the Department.

Final acceptance of the project is contingent upon the removal of the existing traffic signal installation. Removal of the existing traffic signal is part of the work required by the final completion date.

C. Disposal:

Remove all Department traffic signal equipment, span poles, messenger cable, interconnect cable, and supporting hardware that will not be reused. Assume ownership and promptly transport the removed poles, messenger cable, interconnect cable, and supporting hardware. Return all other traffic signal equipment and material to the Traffic Services Office within the Division responsible for the administration of the project.

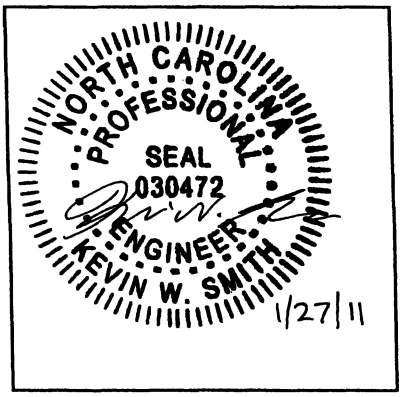
Return the removed equipment and material between the hours of 8:00 a.m. and 12:00 p.m. Monday through Thursday, or at a time mutually agreed upon by the Contractor and the Engineer. Replace or repair all material lost or damaged during its removal and transit. Label all returned equipment and material to indicate its original location.

7.3. MEASUREMENT AND PAYMENT

Actual number of intersections that were completely cleared of all traffic signal equipment. The traffic signal equipment shall have existed along the roadway before the start of construction on the project, shall have had no changes made to the phasing or timing by the Contractor, shall have had no additional equipment installed by the Contractor during the life of the project (excluding equipment for maintenance), and shall have been removed as a part of the project.

Payment will be made under:

Traffic Signal Removal ..... Each



Project Special Provisions
(Version 06.7)
Signals and Intelligent Transportation Systems

Prepared By: KWS / SBP / MWD
27-Jan-11

Contents

1. GENERAL REQUIREMENTS

1.1. DESCRIPTION

Furnish, install, and integrate intelligent transportation system (ITS) deployments along the US-52 corridor (including portions adjacent roadways such as I-40 and US-421) in Winston-Salem, North Carolina. The ITS deployments include new and existing closed circuit television (CCTV) cameras, new and existing dynamic message signs (DMS), and new microwave vehicle detectors (MVD) using new and existing fiber optic communications cable, and new wireless communications links.

Fully integrate video and data from all new and existing ITS devices with the existing software applications at the NCDOT Triad Regional Transportation Management Center (TRTMC) located at 201 South Chimney Rock Road in Greensboro using the existing NCDOT fiber optic network from Winston-Salem to Greensboro. Using their existing communications connections with the TRTMC, integrate video and data from all new and existing ITS devices with the existing software applications at the NCDOT Division 9 Office located at 375 Silas Creek Parkway in Winston-Salem and City of Winston-Salem Traffic Operations Center located at 100 West 5th Street in Winston-Salem.

This ITS work is part of a larger roadway project. The ITS Contractor shall adhere to all requirements of the roadway project, including but not limited to the project schedule, phasing of work, traffic control, and observation period.

1.2. Materials

A. Qualified Products

Furnish new equipment, materials, and hardware unless otherwise required. Inscribe manufacturer's name, model number, serial number, and any additional information needed for proper identification on each piece of equipment housed in a case or housing.

Signal Equipment Qualified Products List (QPL) is available on the Department's website.

Certain field device and communications equipment, material, and hardware shall be pre-approved on the QPL by the date of installation. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project. Consult the QPL web site to obtain pre-approval procedures.

B. Submittal Requirements

Do not fabricate or order material until receipt of the Engineer's approval.

Provide written certification to the Department that all Contractor-furnished material is in accordance with the contract. When requested by the Department, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable Specifications. Ensure additional certification states the testing laboratory is independent of the material manufacturer and neither the laboratory nor the manufacturer has a vested interest in the other.

Identify all proprietary parts in Contractor-furnished material. The Department reserves the right to reject material that uses proprietary components not commercially available through electronic supply houses.

For Contractor-furnished material listed on the QPL, furnish submittals in the format defined by the QPL.

For Contractor-furnished material not on the QPL, furnish three copies of the equipment list including three (3) copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). Ensure material lists contain material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings. Submit for review by the Engineer 40 days prior to installation. Do not fabricate or order material until receipt of the Engineer's approval.

The purpose of the submittal data is to show specifically and in detail how the Contractor intends to satisfy the requirements of these Project Special Provisions and the Plans. If pre-printed literature is used to satisfy some or all of these requirements, cross off and initial statements on the literature which conflict with these Project Special Provisions or Plans. Attach appropriate statements clearly indicating each requirement given in these Project Special Provisions and provide a comparison on how the submittal meets or exceeds the requirements. Clearly label each item of submittal data with the bid item number or other description of the item(s) to which it applies.

Each formal submittal shall contain sufficient information and details to permit the Engineer to fully evaluate the situation. Submittals which are, in the judgment of the Engineer, insufficient to permit proper evaluation will be rejected. Do not deviate from formal submittals marked "Approved" or "Approved as Noted" without the written consent of the Engineer.

Because of the nature of this work, detailed submittal data is required prior to approval of most of the items in order to avoid non-conformance that does not become apparent until it is too late to correct without serious consequences. In addition, because certain groups of items as set forth below are closely interrelated, it is required that the submittals on the items in each group always be made

as a group with complete information being resubmitted each time, if more than one submittal is necessary. Plan the submittal data effort accordingly.

In order to expedite the submittal data process and equipment review, address all of the requirements of these Project Special Provisions and the Plans in the submittal data, leaving nothing to assumption and clearly addressing the functional and technical interrelationships among the various items.

Submittal data for the items in each of the following groups shall be submitted as an integrated unit:

Group A – Fiber Optic Network Cable and Splice Accessories

Group B – Ethernet Communications and LAN Equipment

Group C - Wireless Radio System

Group D –CCTV Camera and Video System

Group E – Microwave Vehicle Detection System

Group F – DMS System

Group G – Truck Rollover System

The items in each of these groups will also be reviewed and approved as an integrated unit. Submittals for items not included in the above groups may be made independently.

The submittal data for all groups shall list the Project Special Provision section and sub-section requirements for each hardware item being considered for use on this project. It shall also show the corresponding data from the hardware item being submitted and how the submittal meets or exceeds the requirements. Attach appropriate documents or statements indicating how the submittal will fulfill the Project Special Provisions. This shall be all-inclusive for each pay item. Hardware submittals that do not address all the requirements in the Project Special Provisions will be rejected for insufficient information.

Plan for any given package of submittal data to be in the hands of the Engineer for forty (40) calendar days. Following review of the submittal data, the Engineer will return to the Contractor one (1) copy or an agreed upon number of the submittal marked "Approved", "Approved as Noted" or "Rejected". The Engineer will also mark each item which must be resubmitted. Proceed with any items marked "Approved". Also proceed with items marked "Approved as Noted" if resubmission is not required. Do not proceed with any items, which are marked "Rejected", or with items for which resubmission is required but shall proceed immediately to correct said items and resubmit them for review. No time extensions shall be granted as a result of the need to resubmit various items for review. Review by the Engineer of various items shall not relieve the Contractor of his obligation to furnish and install the work in accordance with these Project Special Provisions and the Plans.

Develop a submittal data transmittal form and submit the same to the Engineer for approval as to format. Assign a submittal number to each submittal package, which shall be transmitted under the cover of the approved form. The numbering system shall be logical and ascending. Specifically list on the transmittal sheet each item or element included. (An element is one part of several parts of information related to the same line or pay item.) When drawings are submitted, each shall be listed

separately. Completely fill out all portions of the transmittal sheet except those reserved for use by the Engineer. The transmittal sheet will be used by the Engineer to indicate the action taken on the submittal package and a copy of the transmittal sheet showing these actions will be returned to the Contractor. Only clearly related items shall be transmitted under the same transmittal sheet.

C. Observation Period

Warrant workmanship and Contractor-furnished equipment for a 60-day observation period under the payment and performance bond from date of acceptance.

If workmanship or equipment fails during the 60-day observation period, repair or replace with new equipment and begin a new 60-day observation period.

The observation period for this work is not part of the work to be completed by the project completion date.

D. Warranties

Unless otherwise required herein, provide manufacturer's warranties on Contractor-furnished equipment for material and workmanship that are customarily issued by the equipment manufacturer and that are at least two years in length from successful completion of the 60-day observation period. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components, and subroutines which perform any date or time data recognition function, calculation, or sequencing will support a four digit year format for a period of at least 50 years.

Upon successful completion of the 60-day observation period, transfer manufacturer's warranties with proper validation by the manufacturer to the Department or its designated maintaining agency.

E. Firmware Licensing and Upgrades

Provide the Department with a license to duplicate all programmable devices in equipment for maintenance and software upgrades. Provide binary or hexadecimal format files for each device that may be programmed by the Department. Ensure files are provided on PC compatible compact disks or other approved media.

Ensure firmware performance upgrades that occur during the contract period are available to the Department at no additional cost.

Make firmware upgrades that are developed to correct operating characteristics available to the Department at no additional cost until the warranty period expires.

F. Plan of Record Documentation

Before final acceptance, furnish plan of record documentation of all fieldwork. Plan of record documentation will be subject to approval before final acceptance. Store documentation in a manila envelope placed in a weatherproof holder mounted within each cabinet or housing for easy access.

Except for standard bound manuals, bind all 8 1/2" x 11" documentation, including 11" x 17" drawings folded to 8 1/2" x 11", in logical groupings in either 3-ring or plastic slide-ring loose-leaf binders. Permanently label each grouping of documentation.

Provide manual, electrical schematic diagram, and cabinet wiring diagram for each control equipment cabinet and piece of equipment in cabinet. Place manuals and prints in weatherproof holder. For wiring diagrams and electrical schematic diagrams not bound into printed manuals, provide copies at least 22" x 34"

Provide Operator's Manuals containing detailed operating instructions for each different type or model of equipment. Ensure manuals contain instructions for possible modification to equipment.

Provide maintenance procedures manuals containing detailed preventive and corrective maintenance procedures for each different type or model of equipment.

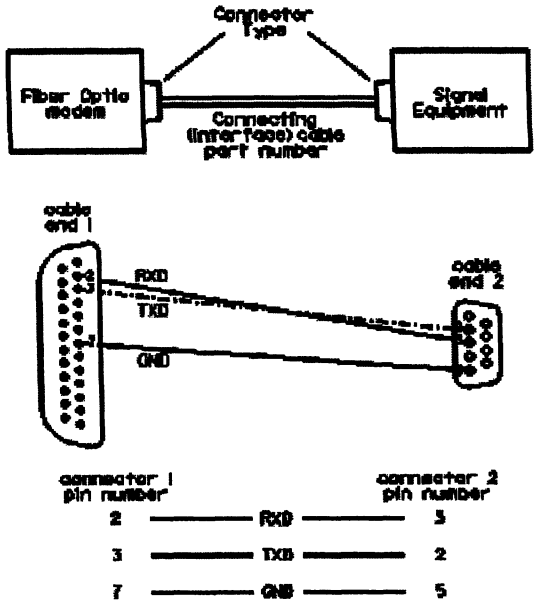
Provide real world coordinates for all ITS devices, splice enclosures, junction boxes, and equipment cabinets installed or utilized under this project. Provide the coordinates in feet units using the North Carolina State Plane coordinate system (1983 North American Datum also known as NAD '83). Furnish coordinates that do not deviate more than 1 7 feet in the horizontal plane and 3.3 feet in the vertical plane. Global positioning system (GPS) equipment able to obtain the coordinate data within these tolerances may be used. Submit cut sheets on the GPS unit proposed to collect the data for approval by the Engineer.

Provide both a digital copy and hard copy of all information regarding the location (including to but not limited to manufacturer, model number, and NCDOT inventory number) in the Microsoft spreadsheet provided by the Department, shown by example below.

NCDOT Inv #	Name	Location	Latitude	Longitude	Manufacturer	Model #
05-0134	Equipment Cabinet	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5500	35.6873	McCain	Type-332
05-0134	Junction Box # 1 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5516	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 2 (Phase 2 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5506	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
5-0134	Junction Box # 3 (Near Cabinet)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5501	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 4 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5486	35.6873	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 5 (Phase 6 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5493	35.6876	Quazite	PG1118BA12(Box) PG118HA00(Cover)
05-0134	Junction Box # 6 (Phase 4 Side)	US 70 at Raynor Rd./ Auburn-Knightdale	-78.5503	35.6879	Quazite	PG1118BA12(Box) PG118HA00(Cover)

Provide detailed wiring diagrams that include interconnection of equipment with pinout configurations, pin functions, and cable parts numbers. For communications systems provide two copies of system connection diagrams showing system interconnection cables and associated terminations.

Example:



G. Wire and Cable

Furnish wire and cable on reels. When requested by the Department, furnish samples of wire and cable to the Department at no additional cost.

Provide either 0.05" x 0.30" aluminum wrapping tape or 0.06" stainless steel lashing wire for lashing cables to messenger cable. Use 0.045" stainless steel lashing wire to lash fiber-optic communications cable to messenger cable.

H. Painting

Where painting of equipment cabinets, poles, and pedestals is required, apply paint at the factory. No field painting will be allowed except when paint has been scratched or marred. In such cases, apply two field coats of the same color and grade enamel as the original paint to the scratched or marred portions.

I. Performance of Warranty Repair and Maintenance

Provide authorization to the TRTMC and Traffic Electronics Center of the North Carolina Department of Transportation (NCDOT) to perform all warranty repairs after project acceptance. The decision to perform warranty work at the Traffic Electronics Center by NCDOT electronics technicians or to have warranty work performed by the vendor shall be at the discretion of the State. Provide any training required by the manufacturer to authorize the Traffic Electronics Center to perform warranty work and ensure manufacturer will furnish parts to the Traffic Electronics Center for all warranty repairs at no cost to the State. In addition, ensure the manufacturer agrees to provide prompt technical support to the NCDOT electronics technicians for a period of one year after the end of the warranty period at no cost to the State. Defective parts replaced under warranty by the Traffic Electronics Center will be returned to the vendor at the vendor's request. Provide schematics, part lists, and other documentation to perform bench repair to the Traffic Electronics Center within two weeks upon request. The Department agrees not to divulge any proprietary information in the

schematics, part lists, and other documentation upon request from the vendor. After project acceptance and at the request of the State, manufacturer shall perform warranty repairs to equipment which fails during the warranty period at no cost to the State including freight costs to ship repaired equipment back to the Traffic Electronics Center. Ensure all equipment is repaired and returned to the Traffic Electronics Center within twenty-one calendar days of receipt by the manufacturer.

1.3. CONSTRUCTION METHODS

A. General

The Engineer shall approve the exact location of each ITS device installation prior to any construction activities at the site.

Before beginning work, verify all existing equipment is in satisfactory working order. Report all defective equipment to the Engineer so as not to be held responsible for defects.

Locate existing conduit, cable runs, inductive detection loops, lead-in, junction boxes, and detection equipment before installing or using equipment that can damage or interfere with such facilities.

Locate all underground utilities before beginning drilling, digging, or trenching operations.

Immediately cease work and notify the Engineer and affected owners if damage to existing utilities, cables, or equipment occurs. Make all required repairs and replacements at no additional cost to the Department.

B. Existing ITS Devices

As part of this project, some existing ITS devices as shown in the Plans will have their existing communications upgraded. The Contractor shall not take any existing device offline until the new communications path (including splicing, field hardware, central hardware, etc.) has been installed and ready for integration.

C. Requirements for Historic Areas

As shown in the Plans, some work will be conducted within areas determined to contain properties with documented historic significance. If it is necessary to deviate from the Plans in these areas, alert the Engineer to contact Project Development And Environmental Analysis Branch-Historic Architecture Group of the North Carolina Department of Transportation for an effects determination before proceeding.

D. Regulations and Codes

Furnish material and workmanship conforming to the NEC, NESC, UL, and all local safety codes in effect on the date of advertisement. Comply with Article 4, Chapter 87 of the North Carolina General Statutes (Licensing of Electrical Contractors). Comply with all regulations and codes imposed by the owner of affected utility poles. In the event of a conflict between the NEC, NESC, UL, local safety codes and these Project Special Provisions, the cited documents will govern.

Where required, conform to ITE, IEEE, AASHTO, and ASTM standards and guidelines in effect on the date of advertisement.

Notify the Engineer, local traffic enforcement agency, local utility company, and affected railroad companies seven business days before operational shutdowns to coordinate connection or disconnection to an existing utility or system.

Install standoffs, meter bases, and service disconnects as required by the NESC, NEC, local utility companies, and local ordinances.

E. Utility Services

Coordinate all work to ensure electrical power of proper voltage, phase, frequency, and ampacity is available to complete the work. Use electrical services cables with THW insulation.

When electrical, telephone, and telecommunication service is not furnished by the Department and is required, contact the utility company and make application to ensure all work can be completed. Obtain authorization for service in the Department's name and make application for service in the Department's name. The Contractor shall begin utility coordination immediately after notice to proceed is given to avoid potential delays to the project.

The Department will be responsible for direct payment of monthly utility company usage charges. The Contractor will be responsible for all expenses associated with utility installation costs, hookups, etc.

F. Maintenance and Repair of Material

Furnish the Engineer with the name, office telephone number, cellular (mobile) telephone number, and pager number of the supervisory employee who will be responsible for maintenance and repair of equipment during all hours.

Maintain and repair all equipment within the project construction limits until completion of the observation period and receipt of written notification of final acceptance of the project. This includes, but is not limited to, field equipment for CCTV cameras, DMS units, MVD units, truck rollover system, wireless radios, and fiber optic communications equipment.

Remove and replace all new and existing equipment that fails. The Department will furnish the Contractor replacement equipment for Department-furnished equipment that fails.

Except for damages and malfunctions caused by the Contractor's work activities, the Contractor will not be held responsible for pre-existing conditions reported to the Engineer before starting work. The Contractor will assume responsibility for all maintenance and emergency services necessary once work has begun and for all damages and malfunctions caused either directly or indirectly by the Contractor's work activities.

G. Removal of Existing Equipment and Material

Remove all Department-owned equipment and material that will not be used. Assume ownership of removed poles, messenger cable, interconnect cable, communications cable, and supporting hardware. Return all other equipment and material between 8:00 a.m. and 12:00 p.m., Monday through Thursday, to the TRTMC.

H. Wire and Cable

For installation in a conduit system, lubricate cable and wires before installing in conduit. Use lubricant that will not physically or chemically harm cable jacket, wire insulation, and conduit.

Splice all electrical wire and cable at recessed-screw, barrier type terminal blocks, in junction boxes, or in condulets. Unless specifically allowed, connect no more than two conductors to the same terminal screw.

Maintain color coding of wires through splices.

Protect ends of wire and cable from water and moisture.

Install all wire and cable with necessary hardware including, but not limited to shoulder eyebolts, washers, nuts, thimbleyelets, three-bolt clamps, J-hooks, split bolt connectors, grounding clamps, and lashing material.

I. Grounding

Provide a grounding system at all new and revised electrical service points unless otherwise specified.

In addition to NEC requirements, test grounding electrode resistance at connection point to electrical service ground bus for a maximum of 20 ohms. Furnish and install additional ground rods to grounding electrode system as necessary to meet test requirements. Submit a completed Inductive Detection Loop & Grounding Test Results form. The form is located on the Department's website.

Provide a length of marker tape 6 to 12 inches below finished grade directly over grounding electrodes and conductors.

J. Electrical Bonding

Using an approved termination means, connect a number 14 AWG minimum 19-strand copper conductor (Type THW) with green insulation to serve as an equipment grounding conductor to metal poles and other metallic components which are not otherwise bonded through means approved by the Engineer.

1.4. REQUIREMENTS FOR CABLES CROSSING RAILROADS

Copies of all executed railroad agreements and related correspondence may be obtained from the Resident Engineer.

A. Railroad Crossings

Do not commence cable routings over or under railroad-owned facilities until notification and coordination with Engineer and the appropriate railroad company has occurred. All affected railroad facilities on this project are owned by the Norfolk Southern Railway Company herein called the Railroad Company. Install fiber optic communications cable as shown on the Plans.

B. Requirements for Insurance

The Contractor will be required to provide coverage conforming to the requirements of the Federal-Aid Policy Guide outlined under 23 CFR 646A for all work to be performed on the Railroad rights(s) of way under the terms of the contract by carrying insurance of the following kinds:

1. Contractor's General Liability and Railroad Protective Liability Insurance

i. Furnish a certificate of general liability insurance and railroad protective liability insurance evidencing a combined single limit of a minimum of $2,000,000.00 per occurrence of general liability insurance and $1,000,000.00 per occurrence of railroad protective liability insurance naming

Norfolk Southern Railway Company as the certificate holder and as an additional insured on both the general and railroad protective liability insurance policy.

ii. If any part of the work is sublet, similar insurance and evidence thereof in the same amounts as required of the Prime Contractor, shall be provided by the subcontractor to cover his operations on railroad right of way. As an alternative, the Prime Contractor may provide for the subcontractor by means of separate and individual policies.

iii. Certificates shall make reference to the project, milepost and county. Certificate description and project designation to include the following information: Installation of fiber optic communications cable over tracks of the Norfolk Southern Railway Company, Durham County (include Railroad Milepost) identified as NC Project 34601.3.6.

Use the address below for the Certificates of Insurance holder:

Norfolk Southern Corporation

Attn. Risk Manager

Three Commercial Place

Norfolk, VA 23510

iv. All policies and certificates shall contain a clause requiring that thirty (30) days written notice be given the Department of Transportation and the Railroad Company prior to cancellation or change. The notices shall make reference to the project, milepost and county.

NOTICE TO:

Norfolk Southern Corporation

Attn. Risk Manager

Three Commercial Place

Norfolk, VA 23510

COPY NOTICE TO:

Department of Transportation

Utilities Coordination Unit

c/o State Railroad Agent

1556 Mail Service Center

Raleigh, NC 27699-1556

v. Carry all insurance herein specified until the final inspection and acceptance of the project, or that portion of the project within railroad right of way, by the Department of Transportation or, in the case of subcontractors, until the Contractor furnishes a letter to the Engineer stating that the subcontractor has completed his subcontracted work within railroad right of way to the satisfaction of the Contractor and the Contractor will accomplish any additional work necessary on railroad right

of way with his own forces. It is understood that the amounts specified are minimum amounts and that the Contractor may carry insurance in larger amounts if he so desires. As to "aggregate limits", if the insurer establishes loss reserves equal to or in excess of the aggregate limit specified in any of the required insurance policies, immediately notify the Department of Transportation and cease all operations until the aggregate limit is reinstated. If the insurer establishes loss reserves equal to or in excess of one/half of the aggregate limit, arrange to restore the aggregate limit to at least the minimum amount stated in these requirements. Any insurance policies and certificates taken out and furnished due to these requirements shall be approved by the Department of Transportation and the Railroad Company as to form and amount prior to beginning work on railroad right of way.

No extra allowance will be made for the insurance required hereunder. The entire cost shall be included in the unit contract bid price for other pay items.

vi. Furnish evidence of insurance as required above for review to the Department of Transportation at the address shown below after which it will be forwarded by the Department of Transportation to the Railroad.

Send to Department:

Department of Transportation

Utilities Coordination Unit

c/o State Railroad Agent

1556 Mail Service Center

Raleigh, NC 27699-1556

C. Delays Caused By Operations of Others

Neither the Department of Transportation nor the Railroad Company assumes any responsibility for any work performed by others in connection with the construction of the project, and the Contractor shall have no claim whatsoever against the Department of Transportation, or the Railroad Company for any inconvenience, delay, or additional cost incurred by him on account of such operations by others.

D. Cooperation with Others

Cooperate with others participating in the construction of the project to the end that all work may be carried on to the best advantage.

E. Authority of Railroad Engineer

The authorized representative of the Railroad Company hereinafter referred to as the Railroad Engineer, shall have the final authority in all matters affecting the safe maintenance of railroad traffic of his company.

F. Interference with Railroad Operations

Arrange and conduct work so that there will be no interference with railroad operations, including train, signal, telephone and telegraphic services, or damage to the property of the Railroad Company or to the poles, wire, and other facilities of tenants on the rights of way of the Railroad Company. Wherever work is liable to affect the operations or safety of trains, the method of doing

such work shall first be submitted to the Railroad Engineer for approval, but such approval shall not relieve the Contractor from liability.

Should conditions arising from or in connection with the work, require that immediate and unusual provisions be made to protect train operations and property of the Railroad Company, it shall be a part of the required services by the Contractor to make such provisions and if, in the judgment of the Railroad Engineer such provisions is insufficient, the Railroad Engineer or the Department of Transportation, may at the expense of the Contractor, require or provide such provisions as may be deemed necessary.

G. Storage of Materials

Materials and equipment shall not be stored where they will interfere with railroad operations, nor on the rights of way of the Railroad Company without first having obtained permission from the Railroad Engineer, and such permission will be with the understanding that the Railroad Company will not be liable or damage to such material and equipment from any cause and that the Railroad Engineer may move or require the Contractor to move, at the Contractor's expense, such material and equipment.

H. Flagging Protection or Watchman Service

The Contractor shall give 72 hours advance notice to the Railroad Company in order that flagging service can be arranged and provided. No work shall be undertaken until the flagman is at the job site.

I. Completion and Acceptance of Work

Upon completion of the work, remove from within the limits of the railroad right of way all machinery, equipment, surplus materials, or rubbish and leave said rights of way in a neat and orderly condition. After the final inspection has been made and work found to be completed in a satisfactory manner acceptable to the Department of Transportation and the Railroad Company, the Department of Transportation will be notified of the Railroad Company's acceptance in writing by the Railroad Company.

1.5. MEASUREMENT AND PAYMENT

There will be no direct payment for work covered in this section. Payment at the contract unit prices for the various items in the contract will be full compensation for all work covered by this section.

2. ELECTRICAL SERVICE

2.1. Description

Install new electrical service where required by the Plans. Coordinate all work involving electrical service with the appropriate electrical utility company.

2.2. Materials

A. General

Material, equipment, and hardware furnished under this section must be pre-approved on the Department's QPL by the date of equipment installation.

Construct electrical service installations in accordance with the Standard Specifications. For locations shown on the Plans requiring new electrical service, provide a service that includes a new external service disconnect (breaker box) and a meter base. Run service cable(s) separately in 1" rigid metallic conduit (RMC). Do not allow the service conductors to share conduits with any other conductors or communications.

For pole mounted cabinets, mount the service on an existing pole as indicated in the Plans, and extend the service cables into the cabinet through a new 1" RMC.

Coordinate with utility company to ascertain the practicality of installing electrical service at each location before performing any work.

B. External Electrical Service Disconnect

Furnish external electrical service disconnects with single pole 50 ampere circuit breaker with a minimum of 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. Ensure service disconnects are listed as meeting UL Standard UL-489 and marked as being suitable for use as service equipment. Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint finish, light gray in color, to yield a minimum thickness of 2.4 mils. Provide ground bus and neutral bus with a minimum of four terminals with minimum wire capacity range of number 14 through number 4

Furnish NEMA Type 3R meter base rated 100 Ampere minimum that meets the requirements of the local utility. Provide meter base with sockets' ampere rating based on sockets being wired with minimum of 167 degrees F insulated wire. Furnish 4 terminal, 600 volt, single phase, 3 wire meter base that complies with the following:

- Line, Load, and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire
- With or without horn bypass
- Made of galvanized steel
- Listed as meeting UL Standard UL-414
- Overhead or underground service entrance as specified

Ensure meter bases have electrostatically applied dry powder paint finish, light gray in color, with minimum thickness of 2.4 mils.

Furnish 1" watertight hub for threaded rigid conduit with meter base.

If meter base and electrical service disconnect are supplied in the same enclosure, ensure assembly is marked as being suitable for use as service equipment. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. Otherwise, ensure combination meter and disconnect is listed as meeting UL Standard UL-67.

2.3. Construction Methods

A. Electrical Service

At locations where new electrical service is to be installed on wood or metal poles, furnish and install electrical service as required by the Plans. After installation of the meter base, the utility company will transfer the existing meter or install a new meter if required and make any necessary connections to the power lines. Ground the new electrical service in accordance with Division 17 of the Standard Specifications and Standard Drawings.

Furnish and install new external service disconnect (breaker box) of the type shown in the Plans. Route the electrical service through the meter base and service disconnect to the controller cabinet to form a complete electrical service assembly as shown in the Plans. Ensure that the existing grounding system for the existing service with the new service disconnect complies with the grounding requirements of these provisions and Division 17 of the Standard Specifications and Standard Drawings.

Provide Engineer with a copy of all permits and final inspections if required.

2.4. Measurement and Payment

New electrical service will be measured and paid as actual number furnished, installed and tested.

No measurement will be made for riser assemblies (1-inch), meter bases, service disconnects, underground and exposed conduit runs to the cabinet, acquisition of service fees, electrical service conductors, ground rod, ground wire and any remaining hardware and conduit to connect the electrical service to the cabinet as these are considered incidental to installing a new electrical service.

Electrical service disconnect will be measured and paid as actual number furnished, installed and tested.

No measurement will be made for riser assemblies (1-inch), underground and exposed conduit runs to the cabinet, conductors, ground rod, ground wire and any remaining hardware and conduit to integrate the disconnect as these are considered incidental to installing the electrical service

disconnect.

Payment will be made under:

New Electrical Service.....Each

Electrical Service Disconnect.....Each

3. MESSENGER CABLE

3.1. Description

Furnish and install messenger cable (spanwire) with cable clamps, machine bolts, eyebolts, 3-bolt clamps, eye nuts, split-bolt connectors, and all necessary hardware.

3.2. Material

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Comply with ASTM A 475 for extra high strength grade wire strand, Class A zinc coating. Fabricate messenger cable from seven steel wires twisted into a single concentric strand.

Provide universal grade strandvises used for extra high strength steel messenger cable. Provide other pole line hardware constructed of hot-dipped galvanized steel. Provide machine bolts, eyebolts, and thimbleye bolts with minimum tensile strength of 12,400 lbs. Provide galvanized nuts, washers, and thimbleyelets.

3.3. Construction Methods

A. General

Install guy assemblies before installing messenger cable.

Use 1/4-inch messenger cable for spans supporting only cables unless otherwise specified.

For messenger cable crossing over railroad tracks, provide a minimum of 27 feet of vertical clearance, unless otherwise specified.

For permanent installations, install messenger cable in continuous lengths with no splices except where an insulator is required. With prior approval, existing messenger for temporary installations may be extended instead of installing new messenger cable.

Tension messenger cable to eliminate appreciable sag and to match sag of surrounding utilities. Otherwise, allow 3 to 4 percent sag of the span length between poles.

Provide three-bolt clamp assemblies consisting of 5/8-inch diameter machine bolts, J-hooks, washers, and square nuts to attach messenger cable to wood poles. Provide machine bolts that are 3 inches longer than the pole diameter.

Attach messenger cable to poles using three bolt cable clamps with J-hooks in mid-runs and deadend strandvises at termination poles.

Maintain electrical continuity at all splices.

B. Messenger Cable for Communications Cable

For messenger cable attached to joint use poles, bond messenger cable to existing pole ground using Burndy clamps (UCG25RS) at ends and at 1300-foot intervals. If existing poles do not have a grounding system, install new grounding system that complies with Article 1720-3 for bonding messenger cable.

On multiple messenger cable arrangements, connect all messenger cable ends with number 6 AWG minimum solid bare copper wire and bond with split bolt connectors or Burndy clamps (UCG25RS) or equivalent and terminate to pole ground.

3.4. Measurement and Payment

Messenger cable (_____) will be measured and paid for as actual horizontal linear feet of messenger cable furnished, installed, and accepted. Measurement will be point to point with no allowance for sag.

No measurement will be made of cable clamps, machine bolts, eyebolts, three-bolt assemblies, eye nuts, split bolt connectors, and pole grounding systems as these will be considered incidental to furnishing and installing messenger cable.

Payment will be made under:

Messenger Cable (1/4") .....Linear Foot

4. UNDERGROUND CONDUIT

4.1. Description

Furnish and install conduit for underground installation with tracer wire, miscellaneous fittings, all necessary hardware, marker tape, backfill, graded stone, paving materials, and seeding and mulching.

4.2. Materials

A. General

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Comply with the Standard Specification Article 1018-2 for backfill and Articles 545-2 and 545-3 for graded stone.

B. High Density Polyethylene Conduit (HDPE)

Provide HDPE conduit with an outer diameter to minimum wall thickness ratio that complies with ASTM D 3035, Standard Dimension Ratio (SDR) 13.6.

Provide conduit that meets the following:

ASTM D 638	Tensile Strength – 3,000 psi, min; Elongation – 400 percent, min
ASTM D 1238	Melt Index – 0.4 maximum
ASTM D 1505	Density – (0.941-0.955g/cc)
ASTM D 1693	Condition B – 20 percent failure, maximum
ASTM D 2444	Impact – NEMA Standards Publication Number TC7
ASTM D 3350	Cell Classification – 334420 or 344420

Ensure HDPE conduit is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate, and transformer oil, and is protected against degradation due to oxidation and general corrosion. Furnish conduit with a coefficient of friction of 0.09 or less in accordance with Telcordia GR-356.

Furnish factory lubricated, low friction, coilable, conduit constructed of HDPE. Furnish conduit with nominal diameter as required. Provide conduit with smooth outer wall and ribbed inner wall. Ensure conduit is capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation without affecting its properties or performance.

Furnish conduit that is suitable for underground use in an ambient temperature range of -30 to 130 degrees F without degradation of material properties.

Dependent upon the number of conduits required, furnish conduits in black, orange, blue and white colors. Provide conduits that are factory extruded with the appropriate colors.

Furnish conduit organizers at all points where multiple conduits enter and exit a junction box or cabinet. Furnish conduit organizers that are appropriately sized with regards to the conduits. Provide conduit organizers that are removable.

C. Conduit Plugs, Pull Line, and Tracer Wire

Furnish duct plugs that provide a watertight barrier when installed in conduit. Furnish duct plugs sized in accordance with conduit. Ensure duct plug provides a means to secure a pull line to the end of the plug. Provide removable and reusable duct plugs.

Furnish mechanical sealing devices that provide a watertight barrier between conduit and cables in conduit. Furnish mechanical sealing devices sized in accordance with conduit and with appropriately sized holes to accommodate and seal cables. Provide removable and re-usable mechanical sealing devices.

Furnish conduit spacers to bind the individual conduits together when installed in a common trench. Furnish conduit spacers that are appropriately sized with regards to the conduits.

Furnish 1/2", pre-lubricated, woven polyester tape, pull line with minimum rated tensile strength of 2,500 lb.

Provide green insulated number 14 AWG, THW, stranded copper wire to serve as tracer wire.

Comply with Subarticle 1400-2(H) Duct and Conduit Sealer.

Furnish non-detectable underground marker tape with the wording "WARNING – Fiber Optic Cable" in all trenches in accordance with the typical drawings in the Plans.

4.3. Construction Methods

A. General

Ensure conduit is free of moisture and debris before pulling cables.

Following installation of conduit where cable is not immediately installed, or conduit is for future use (spare), seal the ends of the conduit with a duct plug. Secure a pull line to the duct plug in such a manner that it will not interfere with installation of the duct plug and provides a watertight seal.

Extend ends of conduit 2 to 4 inches above concrete surfaces and 4 inches above crushed stone bases. For metallic conduit, install metallic bushings and bond conduits.

1. Conduit Entering Junction Boxes

Terminate conduits installed for communications cables in oversized junction boxes. Do not

install other conduits in the oversized junction box unless otherwise specified.

Terminate conduits installed for other cables in standard size junction boxes unless otherwise specified.

For all conduits entering junction boxes, seal spare conduits with approved duct plugs. Seal conduits containing fiber-optic communications cable with mechanical sealing devices. Seal conduits containing other cables with moldable duct seal.

2. Tracer Wire

Install tracer wire in all conduits containing fiber-optic cable. Pull tracer wire simultaneously in a continuous length with the fiber-optic cable. Where multiple pulls of fiber-optic cable are required and conduit is placed in the same trench, only one tracer wire is required. Where multiple pulls of fiber optic cable are required and conduits may separate into individual trenches, install a tracer wire in each conduit run. Provide waterproof butt splices where tracer wire is spliced. Splicing is allowed only in cabinets and junction boxes. Label all tracer wires entering the equipment cabinet.

3. Plan of Record Drawings

Upon completion of the conduit system for communications, furnish the Engineer with a plan of record drawing detailing the horizontal and vertical locations of the conduit system.

B. Trenching

In certain cases the Contractor may use an alternate material other than HDPE and method of installation between trenching and plowing based on existing field conduits and preferences. Obtain approval before proceeding.

1. General

Install PVC, HDPE, or rigid metallic conduit for all underground runs. Install rigid metallic conduit for all underground runs located inside railroad right-of-way Clean existing underground conduit to be incorporated into a new system. Bond all metallic conduit.

If more than one conduit is required between the same points, install conduit in one common trench. Install non-detectable marker tape.

Install longitudinal runs of conduit a minimum of 1 foot from back of curb or 6 feet from edge of pavement in the absence of curb.

Maintain a minimum trench depth of 30 inches below finished grade or 6 inches below roadway subgrade, whichever is deeper.

Extend the ends of the conduits such that upon completion of the installation the conduits will extend a minimum of 2 inches above concrete surfaces and 4 inches above crushed stone bases.

Upon completion, restore surface to like-original condition within seven calendar days of

occurrence of damage. Remove all rock and debris from backfill material. Remove excess material from site and compact area according to Article 300-7. Backfill with excavated material and compact to 95% of original density.

Backfill trench at locations along the trench path where non-movable objects, such as rocks and boulders, cannot be avoided. The purpose of the backfill is to provide a gradual change in elevation of the trench, so that excessive bending and stress will not be transferred to conduits once underground conduit system is installed.

After installation of conduits and upon completion of tamping and backfilling, perform a mandrel test on each conduit to ensure no conduit has been damaged. Furnish a non-metallic mandrel having a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit. Ensure pull line is re-installed.

2. Unpaved Trenching

Install conduit in all unpaved areas. Rake smooth the top 1 1/2 inches seed with same type of grass as surrounding area. Finish unpaved areas flush with surrounding natural ground.

C. Directional Drilling (HDPE Conduit Only)

1. Pre-Approvals and Minimum Depth Requirements

Obtain approval before beginning drilling operations.

At all points where HDPE conduit will traverse under roadways, driveways, sidewalks, or Controlled Access Areas including entrance/exit ramps, maintain a minimum depth of 4 feet or 8 times the back reamer's diameter, whichever is deeper. For an installation that runs parallel to a controlled access area or entrance/exit ramps maintain a minimum depth of 30 inches below finished grade. Maintain a minimum clearance of 30 inches below finished grade when crossing ditch lines. For the following structures, the minimum clearance requirements are:

Man-made Structure	Minimum Clearance Requirement
Bridge foundation	5' horizontal & 4' vertical (clearances greater than minimum horizontal should continue to use the 4V:5H ratio, i.e., 10' horizontal should be no deeper than 8')
Drainage pipes less than 60"	1' above or below [while maintaining a minimum depth of 30" below grade]

Drainage pipes greater than 60"	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Box Culverts	1' above or 4' below [while maintaining a minimum depth of 30" below grade]
Slope protection	2' below
Slope protection foundation footing	5' below

Guarantee the drill rig operator and digital walkover locating system operator are factory-trained to operate the make and model of equipment provided and have a minimum of one year experience operating the make and model of drill rig. Submit documentation of the operators' training and experience for review at least two weeks before start of directional drilling operations.

Provide a means of collecting and containing drilling fluid/slurry that returns to the surface such as a slurry pit. Provide measures to prevent drilling fluids from entering drainage ditches and storm sewer systems. Prevent drilling fluid/slurry from accumulating on or flowing onto pedestrian walkways, driveways, and streets. Immediately remove all drilling fluids/slurry that are accidentally spilled.

2. Directional Drill Operations

Provide grounding for the drill rig in accordance with the manufacturer's recommendations.

Place excavated material near the top of the working pit and dispose of properly. Backfill pits and trenches to facilitate drilling operations immediately after drilling is completed.

Use drill head suitable for type of material being drilled and sized no more than 2 inches larger than the outer diameter of the conduit. Direct drill to obtain proper depth and desired destination. Pressure grout with an approved bentonite/polymer slurry mixture to fill all voids. Do not jet alone or wet bore with water.

During drilling operation, locate drill head every 10 feet along drill path and before traversing underground utilities or structures. Use digital walkover locating system to track drill head during directional drilling operation. Ensure locating system is capable of determining pitch, roll, heading, depth, and horizontal position of the drill head at any point.

Once drill head has reached final location, remove head, and install back reamer of appropriate size (no more than 2 inches larger than outer diameter of conduits) to simultaneously facilitate back reaming of drill hole and installation of conduit. Back reamer is sized larger than actual conduits to ensure conduits are not adversely subjected to deviations caused by the original drill operation and

are as straight as practical in their final position.

The intent of these Specifications is to limit the diameter of the actual drill shaft/hole so that it is no more than 2 inches larger than the conduit outer diameter. The 2-inch larger diameter may be accomplished during the original bore or during the back reaming/conduit installation process.

Once installation of conduit has started, continue installation without interruption so as to prevent conduit from becoming firmly set. Apply bentonite/polymer slurry mixture during conduit installation.

Upon completion of conduit installation, perform a mandrel test on conduit system to ensure conduit has not been damaged. Furnish non-metallic mandrel with a diameter of approximately 50% of the inside diameter of the conduit in which it is to be pulled through. If damage has occurred, replace the entire length of conduit and ensure that pull line is re-installed.

3. Drilling Fluids

Use lubrication for subsequent removal of material and immediate installation of the conduit. The use of water and other fluids in connection with directional drilling operations will be permitted only to the extent necessary to lubricate cuttings. Do not jet alone or wet bore with water. Use drilling fluid/slurry consisting of at least 10 percent high-grade bentonite/polymer slurry to consolidate excavated material and seal drill hole walls.

Transport waste drilling fluid/slurry from site and dispose of in a method that complies with local, state and federal laws and regulations.

4. Conduit Splicing

With prior approval, install a junction box at locations where splicing or coupling of conduit is necessary. Otherwise, splicing or joining of HDPE conduit is prohibited.

4.4. Measurement and Payment

Tracer wire will be measured along the horizontal linear feet of tracer wire furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be made in linear feet.

No payment will be made for excess tracer wire in junction boxes and/or cabinets.

Unpaved trenching (qty, size) will be measured in horizontal linear feet of trenching for underground conduit installation of each type furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

No payment will be made for restoring surface to like-original conditions.

Directional drill (qty, size) will be measured in horizontal linear feet of directional drill for

underground conduit installation furnished, installed, and accepted. Measurement will be along the approximate centerline of the conduit system. Payment will be in linear feet.

No measurement will be made of vertical segments, sealing devices, backfill, graded stone, paved materials, miscellaneous fittings, pull lines, marker tape, mechanical sealing devices, duct plugs, conduit organizers, plan of record drawings, and seeding and mulching as these will be considered incidental to conduit installation.

Payment will be made under:

Tracer Wire .....Linear Foot

Unpaved Trenching (2, 2") .....Linear Foot

Directional Drill (2, 2") .....Linear Foot

5. JUNCTION BOXES

5.1. Description

Furnish and install junction boxes (pull boxes) with covers, graded stone, grounding systems, and all necessary hardware.

5.2. Material

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

A. General

Comply with Article 1411-2 Electrical Junction Boxes except as follows:

Provide junction box covers with standard *NCDOT Fiber Optic* logos (for junction boxes with fiber optic cable) or *NCDOT* logos (for junction boxes with any types of cable), pull slots, and stainless steel pins.

Do not provide sealant compound between junction boxes and covers.

B. Standard Sized Junction Boxes

Provide standard sized junction boxes with minimum inside dimensions of 16"(l) x 10"(w) x 10"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

Vertical extensions of 6" to 12" shall be available from the junction box manufacturer.

C. Oversized Heavy-Duty Junction Boxes

Provide oversized heavy-duty junction boxes and covers with minimum inside dimensions of 30"(l) x 15"(w) x 24"(d) that meet or exceed the Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

5.3. Construction Methods

Comply with Article 1411-3 Electrical Junction Boxes, except as follows:

Install junction boxes flush with finished grade. Do not install sealant compound between junction boxes and covers.

Install junction boxes where underground splicing of cable is necessary and where transitioning from below ground to above ground installation or vice-versa.

5.4. Measurement and Payment

Junction box (_____) will be measured and paid in actual number of junction boxes of each size and type furnished, installed, and accepted.

No measurement will be made of covers, graded stone, and grounding systems as these will be considered incidental to furnishing and installing junction boxes.

Payment will be made under:

Junction Box (Standard Size).....Each

Junction Box (Over-sized, Heavy-Duty) .....Each

6. WOOD POLES

6.1. Description

Furnish and install wood poles with grounding systems and all necessary hardware.

6.2. Material

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Provide 60 foot wood poles for mounting CCTV cameras, with or without the installation of an MVD on the same pole. Provide 40 foot wood poles for mounting only an MVD. Provide 40 foot poles for all other uses as called for in the Plans including utilities and electrical service.

Timber for poles shall meet the requirements of ANSI O5.1 except the timber shall be treated Southern Pine or treated Douglas Fir.

Standard C4 of the American Wood-Preserver's Association will be applicable to the treatment of poles, except that the required retention of preservative will be as below

Give all poles a preservative treatment of either pentachlorophenol, or chromate copper arsenate. The same type of preservative shall be used throughout the entire length of the project.

Minimum retention for poles treated with pentachlorophenol will be 0.45 lb. by assay of dry chemical per cubic foot of wood. Minimum retention for poles treated with chromated copper arsenate will be 0.6 lb. by assay of dry chemical per cubic foot of wood.

6.3. Construction Methods

Mark final pole locations and receive approval before installing poles. Unless otherwise specified, locate poles a minimum of 6 feet behind face of curb or 10 feet from edge of travelway.

Drill or auger a hole for placement of pole and to allow for compacting. Set pole at manufacturer's recommended depth, but at a minimum depth of 5 feet. Ensure the pole is within two degrees of vertical when fully loaded.

Backfill hole with pole installed and tamp backfill in 6 inch lifts with a mechanical tamp until compacted density is at least 95% of original density.

On new Department owned poles, install a grounding system consisting of number 4 or 6 AWG solid bare copper wire that is exothermically welded to a ground rod. Install ground wire so as to minimize damage from vandalism and environmental exposures. Install ground wire up pole to a point adjacent to the uppermost span. Use hot-dipped galvanized wire staples to secure ground wire to pole. Install ground rod at base of pole.

6.4. Measurement and Payment

Wood pole will be measured and paid as the actual number of wood poles furnished, installed, and accepted.

No measurement will be made for installing grounding systems as these will be considered incidental to furnishing and installing wood poles.

Payment will be made under:

Wood Pole.....Each

Wood Pole (CCTV).....Each

Wood Pole (MVD).....Each

7. GUY ASSEMBLIES

7.1. Description

Furnish and install guy assemblies with all necessary hardware.

7.2. Material

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Furnish guy assemblies with anchor assemblies, guy cable, and guy cable guard.

Provide anchor assemblies with all miscellaneous hardware consisting of either expanding anchor with rod and tripleye attachment, screw anchor with extension rod and tripleye attachment, or expanding rock anchor with tripleye attachment. Ensure anchor assembly size is adequate for site conditions. Provide rods constructed of hot-dipped galvanized steel sized according to the soil bearing conditions in the area. Provide tripleye guy attachments constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may be used in lieu of those with the tripleye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet minimum in length.

For type of anchor assembly furnished, ensure the following:

- Expanding anchor - provide steel construction with protective paint or heat shrink of 6 mil plastic to protect metal during shipping and storage.
- Screw anchor - provide hot-dipped galvanized steel construction.
- Expanding rock anchors - provide malleable iron and rust-resisting paint construction.

Provide 3-bolt clamp fabricated from galvanized steel with minimum length of 5 3/4". Ensure clamp has parallel grooves (one on each side of bolt holes) for cable placement. Provide three 1/2" diameter galvanized bolts and nuts to tighten the clamp around the messenger cable. Ensure clamp fits 1/4" to 3/8" messenger cable.

Provide full round guy cable guards that are 8 feet in length and constructed of ultraviolet stabilized, high impact, bright yellow, high density polyethylene.

Provide guy cables consisting of messenger cable of the same size as the largest sized messenger cable to be guyed. Comply with the Messenger Cable section of these Project Special Provisions.

7.3. Construction Methods

A. General

Install guy assemblies with guy cable, guy guards, anchors, three-bolt clamps and associated fittings. Use two-bolt attachment method where there is adequate room on the pole to comply with the NESC. Attach guy assembly and guy cable to two separate bolts with one bolt for span and one bolt for guy cable.

Where adequate spacing is not available and a violation of the NESC would occur with the two-bolt attachment method, use approved one-bolt attachment method for attaching messenger cable and guy assembly.

Bond guy assembly to new pole grounding system as described in Section 1710-3 of the Standard Specifications.

Do not attach to existing guy assemblies unless specifically approved by owner.

B. Guy Assemblies for Communications Cable

When installing messenger cable for supporting only communications cable, use approved one-bolt attachment method for attaching messenger cable and guy assembly

Bond guy assembly to existing pole ground using Burndy Clamp (UCG25RS) or equivalent. If existing poles do not have a grounding system, install new grounding system for bonding guy assembly that complies with Article 1720-3 of the Standard Specifications.

Do not attach to existing guy assemblies unless specifically approved by owner.

7.4. Measurement and Payment

Guy assembly will be measured and paid as the actual number of guy assemblies furnished, installed, and accepted.

No measurement will be made of guy cable, guy guards, anchors, clamps, or fittings as these will be considered incidental to furnishing and installing guy assemblies.

Payment will be made under:

Guy Assembly.....Each

8. RISER ASSEMBLIES

8.1. Description

Furnish and install riser assemblies with clamp-on, aluminum weatherheads or heat shrink tubing, galvanized pole attachment fittings, and all necessary hardware.

8.2. Material

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Provide rigid metallic conduit for risers. Provide rigid hot dipped galvanized steel conduit that meets UL Standard 6 Electrical Rigid Metal Conduit-Steel with rigid full weight sherardized or galvanized threaded fittings.

Provide Tyco™ (Raychem™) part number 066193-000 or equivalent heat shrink tubing for the installation of fiber-optic or coaxial cable in new risers.

Provide Tyco™ (Raychem™) part number FOSC-ACC-CABLE-SEAL-2-NW or equivalent heat shrink tubing retrofit kits for the installation of new fiber-optic or coaxial cable in existing riser with existing fiber-optic or coaxial cables.

8.3. Construction Methods

Install risers with required weatherheads or heat shrink tubing on poles using pole attachment fittings.

Install heat shrink tubing retrofit kits in existing risers as specified.

Use separate 2-inch riser with heat shrink tubing for fiber-optic communications cables and coaxial cable. Install risers with heat shrink tubing so that cable can be installed without violating its minimum bending radius. Install cable so it does not share a riser with any other cable.

Use separate 2-inch riser with weatherhead for other cables.

Install heat shrink tubing in accordance with manufacturer's recommendations. Provide tubing a minimum of 5 inches in length with a minimum of 2.5 inches extended over cables and 2.5 inches extended over risers after heat has been applied. Use nylon filler rods with UV protection or equivalent, and sealing spacer clips to separate cables where multiple cables enter a riser. Ensure sealing spacer clips have a heat activated sealing compound with the sealing compound fully encapsulating the space between cables. Ensure heat shrink tubing provides a watertight fit around individual cables and outer walls of risers. Do not use cut sections of cable or any other devices in lieu of filler rods. Use aluminum tape around cables to prevent damage from sealing chemicals. Use a heat source that will provide even heat distribution around tubing. Ensure no damage occurs to any cables.

Transition from the rigid galvanized steel risers to underground PVC conduits using an approved rigid galvanized steel sweeping elbow with PVC female adaptor.

8.4. Measurement and Payment

__" *Riser with* _____ will be measured and paid as the actual number of risers of each type and size furnished, installed, and accepted.

No measurement will be made of weatherheads, heat shrink tubing, or pole attachment fittings as these will be considered incidental to furnishing and installing risers.

Payment will be made under:

2" Riser with Weatherhead .....Each

2" Riser with Heat Shrink Tubing .....Each

9. FIBER-OPTIC CABLE

9.1. Description

Furnish and install single mode fiber-optic (SMFO) communications cable and drop cable assemblies with grounding systems, fiber-optic cable storage racks (snow shoes), communications cable identification markers, lashing wire, and all necessary hardware.

9.2. Material

A. SMFO Communications Cable

Furnish loose tube fiber-optic cable with required fiber count that complies with RUS CFR 1755.900, single mode with dielectric central member. Use single mode fiber in cable that does not exceed attenuation of 0.25 dB/km at 1550 nm and 0.35 dB/km at 1310 nm. Provide cable with all fibers that are useable and with surface sufficiently free of imperfections and inclusions to meet optical, mechanical, and environmental requirements. Provide cable with minimum of one ripcord under sheath for easy sheath removal and with shipping, storage, installation, and operating temperature of at least -40 to 160 degrees F with a dual layered, UV cured acrylate fiber coating applied by cable manufacturer that may be stripped mechanically or chemically without damaging fiber.

Provide fibers inside loose buffer tube. Use doped silica core surrounded by concentric silica cladding for each fiber. Distinguish each fiber and buffer tube from others by means of color coding that meets EIA/TIA-598 Color Coding of Fiber-Optic Cables. In buffer tubes containing multiple fibers, ensure colors are stable during temperature cycling and not subject to fading, sticking, or smearing into each other or into gel filling material. Use fillers in cable core if necessary to provide a symmetrical cross-section of cable. Fill buffer tubes with non-hygroscopic, nonnutritive to fungus, electrically non-conductive, homogenous gel. Ensure gel is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide a central member consisting of a dielectric glass reinforced plastic rod. Apply binders with sufficient tension to secure buffer tubes and binders to the central member without crushing buffer tubes. Ensure that binders are non-hygroscopic, non-wicking (or rendered so by the flooding compound), and dielectric with low shrinkage.

Provide cable that has cable core interstices filled with super-absorbent, waterblocking compound that is non-conductive and homogenous. Ensure compound is free from dirt and foreign matter, and is removable with conventional nontoxic solvents.

Provide cable with high tensile strength aramid yarns or fiberglass yarns that are helically stranded evenly around cable core.

Provide cable jacket of consistent thickness that is free of holes, splits, and blisters, and contains no metal elements. Provide outer jacket of medium density polyethylene with minimum nominal sheath thickness of 0.050 inch. Ensure polyethylene contains carbon black for ultraviolet light protection and does not promote fungus growth.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure character height of the markings is approximately 0.10".

B. Drop Cable

Furnish drop cable assemblies to provide communications links between splice enclosures and transceivers through interconnect centers. Furnish drop cable assemblies containing a minimum of six individual fibers.

Furnish drop cable assemblies that comply with RUS-CFR 1755.900. Ensure drop cable assemblies have the same operating characteristics as the SMFO cable it is to be coupled with.

On one end of cable assemblies, furnish six ST-PC connectors for termination on connector panel in equipment cabinet. Provide either factory assembled drop cables with ST-PC connectors or field installed connectors.

Ensure attenuation of drop cable at 1310 nm does not exceed 0.5 dB/km. Ensure attenuation loss for complete drop cable assembly does not exceed a mean value of 1.5 dB.

Provide length markings in sequential feet and within one percent of actual cable length. Ensure character height of markings is approximately 0.10".

C. Communications Cable Identification Markers

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable that do not slide or move along the surface of the cable once installed. Ensure exposure to UV light and weather does not affect the markers natural coiling effect or deteriorate performance. Provide communications cable wraps that permit writing with an indelible marking pen and contain the following text in black:

WARNING
NCDOT FIBER OPTIC CABLE
CONTACT TELEPHONE NUMBER: _____
WARNING
NCDOT FIBER OPTIC CABLE

Overall Marker Dimensions: 7"(l) x 4"(w)
Lettering Height: 3/8 inch for *WARNING*, 1/4" for all other lettering

Submit a sample of proposed communications cable identification markers to the Engineer for approval before installation.

D. Fiber-Optic Cable Storage Guides

Furnish fiber-optic storage guides (snowshoes) that are non-conductive and resistant to fading when exposed to UV sources and changes in weather. Ensure snowshoes have a captive design such that fiber-optic cable will be supported when installed in the rack and the minimum bending radius will not be violated. Provide stainless steel attachment hardware for securing snowshoes to messenger cable and black UV resistant tie-wraps for securing fiber-optic cable to snowshoe. Ensure snowshoes are stackable so that multiple cable configurations are possible.

9.3. Construction Methods

A. General

Provide cable manufacturer's attenuation and Optical Time Domain Reflectometer (OTDR) testing data for each reel of cable upon request.

Install SMFO communications cable, snow shoes, communications cable identification markers, lashing wire, and all necessary hardware.

Comply with manufacturer's recommendations. Install communications cable on signal poles, utility poles, messenger cable, and in conduits as required to bring the fiber-optic cable into and, if necessary, out of each splice enclosure.

Take all precautions necessary to ensure cable is not damaged during storage, handling, and installation. Do not violate minimum bending radius of 20 times the radius of cable diameter or manufacturer's recommendation, whichever is greater. Do not step on cable nor run over cable with vehicles or equipment. Do not pull cable over or around obstructions, or along the ground.

Determine lengths of cable necessary to reach from termination-point to termination point. Install cable in continuous lengths between approved splicing facilities. Additionally, provide a sufficient amount of slack cable to allow for an additional 20 feet of cable to be present after removal of outer sheath for termination. Measure slack cable by extending cable straight out of cabinet door.

Keep cable ends sealed at all times during installation to effectively prevent the ingress of moisture. Use approved heat shrink cable end cap. Do not use tape to seal cable ends.

Before installing cable, provide three copies of cable manufacturer's recommended and maximum pulling tension. Do not exceed manufacturer's recommended pulling tension. Use pulling grips containing a rotating swivel. Coil cable in a figure-8 configuration whenever cable is unreeled for subsequent pulling.

Install fiber-optic cable in separate 2-inch risers with heat shrink tubing or conduits. Do not share risers or conduits containing fiber-optic cable with other type cable.

B. Aerial Installation

Double lash fiber-optic cable to messenger cable with one 360 degree spiral per foot.

Use pole attachment hardware and roller guides with safety clips to install aerial run cable.

Maintain tension during the pulling process for aerial run cable by using an approved mechanical clutch (dynamometer) device. Do not allow cable to contact the ground or other obstructions between poles during installation. Do not use a motorized vehicle to generate cable pulling forces.

Use a cable suspension clamp when attaching cable tangent to a pole. Select and place cable blocks and corner blocks so as not to exceed the cable's minimum bending radius. Do not pull cable across J-hooks.

Store 100 feet of each fiber-optic cable on all cable runs that are continuous without splices where specified. Obtain approval for spare cable storage locations. Store spare fiber-optic cable on

fiber-optic cable storage racks (snow shoes). Locate spare cable storage in the middle of spans between termination points. Do not store spare fiber optic cable over the roadway or driveways.

Install one communications cable identification marker within 36 inches of pole attachment points and at locations where more than one cable originates or terminates.

C. Underground Installation

Install fiber-optic cable underground in conduit using cable pulling lubricants recommended by the fiber-optic cable manufacturer.

Obtain approval of cable pulling lubricant and method of pulling before installing underground fiber-optic cable.

Use a dynamometer (clutch device) so as not to exceed maximum allowable pulling tension if cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable pulling forces.

Keep tension on cable reel and pulling line at start of each pull. Do not release tension if pulling operation is halted. Restart pulling operation by gradually increasing tension until cable is in motion.

For pulling cable through manholes, junction boxes, and vaults, feed cable by manually rotating the reel. Do not pull cable through intermediate junction boxes, handholds, or openings in conduit unless otherwise approved.

Install communications cable identification markers on each communications cable entering a junction box.

D. Installation of Drop Cable Assembly

Determine length of drop cable needed, including slack, to reach from termination point to termination point.

At aerial splice enclosures, store 100 feet of slack cable on cable storage racks. At below ground splice enclosures, coil 100 feet of slack cable in manhole or junction box where enclosure is located.

At equipment cabinet end of drop cable assembly, terminate all fibers with ST-PC connectors to the connector panel. Label all connectors, pigtails, and the connector panel. At the aerial splice enclosure location, cap off all unused fibers and label to correspond with the connector panel.

E. Reuse of Existing Fiber Optic Cable:

At several locations, existing fiber optic cable owned by NCDOT and/or the City of Winston-Salem is called for reuse under this project. The Contractor shall notify the Engineer a minimum of seven (7) days prior to splicing, reconnecting at patch panels, or performing any activity that would otherwise modify the operation of the existing cable. The Contractor shall provide the Engineer with, the in writing of the location of the affected cable and the estimated duration for which the cable will be affected. The Contractor shall be responsible for testing existing optical fibers intended for reuse from the nearest accessible terminated end to the location points the cable is intended for reuse. The Contractor shall report in writing to the Engineer any fibers proposed for reuse that do not meet the operating standards called for in the Standard Specifications. The Contractor shall verify prior to disruption of any service the nature and character of the use of each optical fiber that may be cut or otherwise affected and report these uses to the Engineer.

If the Contractor finds that any existing interconnect centers to be reused do not meet the optical standards of the communications cable, the Contractor shall notify the Engineer and the Department will investigate and correct the issue or replace the existing interconnect center within fourteen (14) days of notification.

9.4. Measurement and Payment

Communications cable (____fiber) will be measured and paid as the actual linear feet of fiber-optic cable of each fiber count furnished, installed, and accepted. Measurement will be made by calculating the difference in length markings located on outer jacket from start of run to end of run for each run. Terminate all fibers before determining length of cable run.

Drop cable will be measured and paid as linear feet of fiber-optic drop cable assemblies furnished, installed, and accepted. Sag and vertical segments will not be paid for as these distances are considered incidental to the installation of drop cable assemblies.

No measurement will be made for terminating, splicing, and testing fiber-optic cable, communications cable identification markers, or fiber-optic cable storage racks, as these will be considered incidental to the installation of fiber-optic cable.

Payment will be made under:

Communications Cable (12 Fiber) ..... Linear Foot

Communications Cable (72 Fiber) ..... Linear Foot

Communications Cable (144 Fiber) ..... Linear Foot

Drop Cable ..... Linear Foot

10. FIBER-OPTIC SPLICE CENTERS

10.1. Description

Furnish and install fiber-optic interconnect centers, fiber-optic splice enclosures, and all necessary hardware.

10.2. Materials

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

A. Interconnect Center

Furnish compact, modular interconnect centers designed to mount inside equipment cabinets. Design and size interconnect centers to accommodate all fibers entering cabinets.

Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside splice tray. Design and size splice trays to be dielectric, to accommodate all fibers entering splice tray, and to provide sufficient space to prevent microbending of optical fibers. Provide connector panels with ST-type connectors.

Furnish SMFO pigtails with each interconnect center. Provide pigtails containing connector panels that are a maximum of 6 feet in length with a factory assembled PCST connector on one end. Ensure SMFO pigtails meet the operating characteristics of the SMFO cable with which it is to be coupled.

Furnish SMFO jumpers that are a minimum of 3 feet in length with factory assembled PC-ST connectors on each end. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

B. Splice Enclosure

Furnish splice enclosures that are re-enterable using a mechanical dome-to-base seal with a flash test valve, and are impervious to the entry of foreign material (water, dust, etc.). Ensure enclosures are manufactured in such a manner to be suitable for aerial, pedestal, buried, junction box, and manhole installation.

Provide enclosures with a minimum of one over-sized oval port that will accept two cables and with a minimum of four round ports (for single cables) that will accommodate all cables entering enclosure. Provide heat shrink cable shields with enclosure to ensure weather tight seal where each cable enters enclosure.

Within enclosures, provide enough hinged mountable splice trays to store the number of splices required, plus the capacity to house six additional splices. Provide a fiber containment basket for storage of loose buffer tubes expressed through the enclosure. Ensure enclosures allow sufficient space to prevent microbending of buffer tubes when coiled.

Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside splice tray. Provide splice trays that are dielectric.

10.3. Construction Methods

A. General

Install interconnect centers with connector panels, splice trays, storage for slack cable or fibers, mounting and strain relief hardware, and all necessary hardware.

Install splice enclosures with splice trays, basket containment assemblies, racking for slack cable or fibers, mounting and strain relief hardware, and all other necessary hardware.

Fusion splice and secure SMFO cable in splice trays inside the splice enclosure. Ensure all buffer tubes are contained within splice trays so no bare fibers are outside tray.

Do not exceed 0.05 dB of attenuation per splice.

Furnish strain relief so that no tensile force is on SMFO cable when it is held within the interconnect center or splice enclosure.

Do not damage fiber or violate the minimum bending radius of the fiber.

B. Termination and Splicing within Interconnect Center

Terminate and splice all fibers including unused fibers.

Label all fiber-optic connectors, whether on jumpers, connector panels, or other equipment, to prevent improper connection. Obtain approval of fiber-optic connector labeling method.

For all fibers designated for termination to connector panel within interconnect center, fusion splice fibers to pigtails.

For all cut fibers designated to pass through interconnect center, fusion splice fibers.

For all buffer tubes designated to pass through interconnect center, neatly coil excess tubing inside interconnect center.

C. Termination and Splicing within Splice Enclosure

Fusion splice all fibers including fibers designated to be coupled with fibers from a drop cable assembly and cut fibers designated to pass through splice enclosure.

For all buffer tubes designated to pass through splice enclosure, neatly coil excess tubing inside basket provided with enclosure.

Label all fiber-optic splices. Obtain approval of fiber-optic connector labeling method.

Install heat shrink cable shields using methods recommended by the manufacturer of the enclosure. Perform a pressurization flash test on enclosure in accordance with manufacturer's recommended procedures at the conclusion of splicing procedure and before final placement of enclosure.

For aerial installations, secure enclosures to messenger cable using manufacturer supplied hardware. Secure SMFO cable and drop cable assemblies to snowshoes.

Install enclosures with enough slack cable to allow enclosure to be lowered to ground level and extended into a splicing vehicle.

For underground, manhole, and junction box facility installations, place the enclosure along with required spare cables in the facility in a neat and workmanship like manner.

D. Modify Existing Splice Enclosure:

At locations shown in the Plans, the Contractor shall reuse an existing splice enclosure or cabinet to facilitate the splicing of an additional communications cable. The Contractor shall ensure that all existing, unmodified splices are functional and operating in their same condition after performing any work in an existing splice enclosure or cabinet. The Contractor shall also ensure that any modifications do not cause downtime of the terminating communication cables and ITS devices as described in the Intermediate Contract Times and Liquidated Damages of the Contract documents.

10.4. MEASUREMENT AND PAYMENT

Interconnect center will be measured and paid as the actual number of fiber-optic interconnect centers furnished, installed, and accepted.

Splice enclosure will be measured and paid as the actual number of fiber-optic splice enclosures furnished, installed, and accepted. No measurement will be made between aerial, underground, manhole, or junction box installation of the fiber-optic splice enclosure.

Modify existing splice enclosure will be measured and paid ad the actual number of enclosures modified and accepted.

No measurement will be made of splice trays, pigtails, jumpers, connector panels, and testing, as these will be considered incidental to furnishing and installing fiber-optic interconnect centers and splice enclosures.

Payment will be made under:

Interconnect Center ..... Each

Splice Enclosure ..... Each

Modify Existing Splice Enclosure ..... Each

11. DELINEATOR MARKERS

11.1. Description

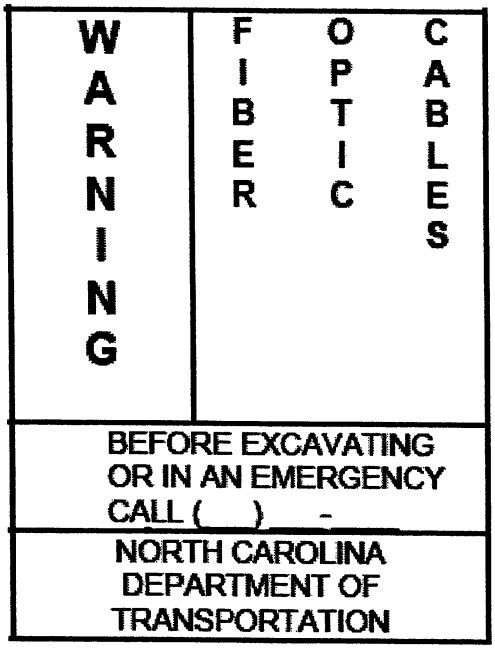
Furnish and install delineator markers with all necessary hardware.

11.2. Material

Material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Furnish tubular delineator markers, approximately 6 feet long, and constructed of Type III, high density polyethylene material. Provide delineator assemblies that are ultraviolet stabilized to help prevent components from color fading, warping, absorbing water, and deterioration with prolonged exposure to the elements. Provide delineators designed to self-erect after being knocked down or pushed over. Provide orange delineator posts.

Provide text, including division contact number, hot stamped in black on a yellow reflective background material that will not fade or deteriorate over time. Provide delineator markers with nominal message height of 15" that contain the following text visible from all directions approaching the assembly:



11.3. Construction Methods

Submit sample of proposed delineator markers for approval before installation.

Install delineator markers using a method that firmly and securely anchors delineator marker in the ground to prohibit twisting and easy removal.

11.4. Measurement and Payment

Delineator marker will be measured and paid for as the actual number of delineator markers furnished, installed, and accepted.

Payment will be made under:

Delineator Marker .....Each

12. MODIFY CABINET FOUNDATIONS

12.1. DESCRIPTION

Where approved by the Engineer, install conduit entrances into existing foundations in accordance with the Plans and Project Special Provisions.

12.2. CONSTRUCTION METHODS

A. Install Conduit Entrance into Existing Foundation:

Install Conduit Entrances into existing cabinet foundations by core drilling foundations to install additional conduit.

Maintain a minimum of 3 inches of cover between new conduit and edge of foundation. Maintain minimum clearances of 1 inch from the flange of the base adapter and 2 inches from existing conduits. Avoid damaging existing conduit, conductors, and anchor bolts. Repair all such damages. Where approved by the Engineer, the foundation may be chipped instead of drilled for conduit entrance. When possible, maintain operations of existing equipment while drilling is performed.

Bond new metallic conduit to the cabinet grounding system.

After installation of conduit, place grout to seal around conduit, and return the foundation to normal appearance.

12.3. MEASUREMENT AND PAYMENT

Conduit entrance into existing foundation will be measured and paid for as the actual number of conduit entrances drilled into existing cabinet foundations furnished, installed and accepted.

Payment will be made under:

Conduit Entrance into Existing Foundation.....Each

13. MICROWAVE VEHICLE DETECTOR

13.1. DESCRIPTION

Furnish and install a microwave vehicle detection hardware and software with manufacturer recommended cables in accordance with the Plans and Project Special Provisions.

13.2. MATERIALS

A. General

Provide an MVD assembly for the project site that consists of microwave radar sensor(s) in enclosed housing(s) (i.e., the detectors), as shown in the Plans and directed by the Engineer. Provide an installation kit with mounting brackets; cable for the transmission and receipt of data and communications between the field detector and the communication system hardware; and all required power and data cables, as detailed in Plans.

B. Detector

Provide an MVD that uses a Federal Communications Commission (FCC)-certified, low-power microwave radar beam to detect vehicle passage and generate volume, occupancy, length-based classification, and speed data. Ensure that the MVD is a true-presence microwave radar that uses the frequency modulated continuous wave (FMCW) principle. Ensure that any non-background targets reflect the signal back to the microwave radar detector, where the targets are detected and their range measured.

Ensure that the MVD provides speed-trap emulation and has the ability to detect automatically sensor settings, baud rates, loop spacing, and communication port settings to select an operational mode.

Ensure that the detector has the ability to self-tune and allow manual calibration via supplied vendor software. Ensure that the MVD is capable of auto-calibration and auto-configuration, and that it does not transmit any signals outside its FCC-approved frequency. Provide a setup program that allows the operator to define detection zones within the detector's field of view. Ensure that the detector automatically configures zones, requiring minimal external tuning. Verify that the unit is not adversely affected by varied weather conditions, such as rain, fog, heat, or wind.

Ensure that the MVD can compute, store, and provide all required traffic parameter measurements per detection zone in user-selected time intervals from 0 to 60 minutes, including, but not limited to, 10 seconds, 20 seconds, 30 seconds, 60 seconds, 5 minutes, 10 minutes, 15 minutes, 30 minutes, and 60 minutes. The MVD shall log and store vehicle volume, occupancy, length-based classification and speed data for a minimum of seven days regardless of collection interval. Data storage within the MVD shall utilize a first in/first out architecture such that the oldest stored data record is overwritten with the newest data record when the storage device is at full capacity.

5. Communications

Ensure that the MVD generates and transmits traffic data in a native Internet Protocol (IP) interface. The MVD shall have an Ethernet port for communications and a serial port for a user laptop connection.

Ensure that the MVD can generate contact closures emulating the output of a pair of 6 foot by 6 foot loops with leading edges placed 16 feet apart.

Verify that the MVD is IP addressable. Ensure that all device communication addresses are user programmable.

Ensure that the MVD supports Ethernet protocols. Ensure that the setup program assigns an IP address to the detection unit. Ensure that the MVD responds to a polling request for traffic data from the TRTMC, Division 9 Office, or City of Winston-Salem. Verify that the detection unit responds with the accumulated traffic parameter measurements from the period since the last request was issued.

Verify that the MVD stores all system configuration and traffic parameter data within internal nonvolatile memory. Verify that traffic data can be locally and remotely transferred by issuing requests from a personal computer (PC) across the communication network connecting the detector and the operator workstation or other PC.

6. Configuration and Management

Ensure that the MVD software application provides PC desktop display of the detection zones and control of any vehicle detector connected to the network. Ensure that the MVD setup program enables the operator to select whether data is output as contact closures emulating standard loop detector outputs, and/or as accumulated statistical data using detector serial ports.

Verify that the sensor holds a vehicle's presence in the specified detection zone until the vehicle is clear of the zone. Ensure that the sensor does not tune out stationary vehicles within a detection zone and thereby give a false clear status to the lane, even if a vehicle has stopped for a period exceeding 30 minutes. Provide detectors that are capable of resolving closely spaced vehicles.

Provide software licenses for the TRTMC, Division 9 Office, and City of Winston-Salem.

Ensure that an operator using a locally connected laptop computer can conduct system setup, calibration, diagnosis, and data retrieval operations. Ensure that the MVD is capable of having its configuration data saved to a laptop computer, which can later transfer the data back to the MVD for reloading.

Ensure that the MVD operator can use a laptop computer to edit previously defined detection configurations to permit adjustments to the detection zone's size, placement, and sensitivity, and to reprogram the detector's parameters.

Ensure that the laptop computer and the MVD can communicate when connected directly by an EIA-232 cable. Ensure that the MVD can communicate across the communication network using NTCIP standards.

Once programmed, ensure that no periodic adjustments are required to the detection zones unless physical roadway conditions change, such as lane shifts or closures.

7. Electrical Requirements

Ensure that the MVD field hardware meets the requirements in the FCC's 2005 Code of Federal Regulation (CFR), Title 47, Part 15. The detector shall not interfere with any known equipment.

Ensure the MVD operates using a nominal input voltage at the field cabinet of 120 volts of alternating current (VAC). Ensure that the system's power supply will operate with an input voltage

ranging from 89 to 135 VAC. For any device requiring a source input other than the standard 120 VAC, supply the appropriate means of conversion.

Provide an assembly manufactured in such a way as to prevent reversed or improper installation. Ensure that the MVD design provides high-voltage exposure protection to personnel during equipment operation, adjustments, and maintenance.

Furnish all equipment with the appropriate power and communication cables. Install the power cable and the communication cables according to the manufacturer's recommendation. Ensure that the cables comply with NEC sizing requirements as presented in NEC Article 210-19(a), Fine Print Note (FPN) No. 4, and meet all other applicable standards, specifications and local code requirements.

Ensure that the power cable running between the MVD and its electrical service is in a separate conduit. Do not install communication cables in the same conduit as power cables carrying voltage greater than 24 VDC/VAC or current in excess of 1.5 amps. Do not install the power and communication cables in the same pull boxes.

Cut all wires to their proper length before assembly. Do not double back any wire to take up slack. Neatly lace wires into cables with nylon lacing or plastic straps. Secure cables with clamps and provide service loops at all connections.

In the event that power to the MVD or a subcomponent thereof is interrupted, ensure that the equipment automatically recovers after power is restored. Ensure that all programmable system settings return to their previous configurations and the system resumes proper operation.

Ensure that the MVD operator is able to select and use 12 to 24 volts of direct current (VDC) and 115 VAC at 60 Hz.

Ensure that the detector is FCC certified and that the FCC's identification number is displayed on an external label. Ensure that the detector transmits within a frequency band of 10.525 gigahertz, ±25 megahertz, or another FCC approved spectral band.

8. Environmental Requirements

Provide MVDs that meets all specifications during and after being subjected to an ambient operating temperature range of -30 degrees F to 165 degrees F with a maximum non-condensing relative humidity as defined in the environmental requirements section of the NEMA TS 2 standard.

Verify that the MVD manufacturer certifies that its device has successfully completed environmental testing as defined in the NEMA TS 2 standard. Verify that vibration and shock resistance meet the requirements of Sections 2.1.9 and 2.1.10, respectively, of NEMA TS 2.

Ensure that no item, component, or subassembly emits a noise level exceeding the peak level of 55 decibels adjusted (dBa) when measured at a distance of 3.3 feet away from its surface.

Ensure that MVD components comply with the environmental requirements detailed in the NEMA TS 2 standard.

9. Detector Housing

Furnish and install an environmentally resistant and tamper-proof sensor enclosure for any detector assembly exposed to the elements. Ensure that the enclosure is environmentally sealed upon installation and that it is light in color.

10. Performance

Provide MVD devices calibrated by lane for each device to meet the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, 90% for length based classification and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer.

C. Software

Provide client-server software to perform the following tasks:

- Device configuration and setup,
- Diagnostic testing,
- Device management,
- Data retrieval, analysis, reporting and storage,
- Data importing from NCDOT's MVD database,
- Data exporting to other systems, including but not limited to:
    - Dynamic Message Signs for travel time posting, and
    - NCDOT for posting on a speed map.

Provide software to collect data from each sensor as frequently as 20-second intervals.

The report function shall include user-definable queries in graphical, text and tabular formats.

The software shall perform database translations, data types and file formats to accomplish the above data exporting. The software should utilize the following minimum file formats: XML, HTML, SQL, Excel, and PDF. Software shall include "on-demand" and scheduled data translation.

D. Application Server

The Department shall furnish application servers for the MVD software to the Contractor. The Contractor shall install and integrate the servers and software to form a fully functioning MVD system. If the Department-furnished server does not meet the minimum requirements of the MVD software, the Contractor shall be fully responsible for all necessary upgrades or replacements. The Contractor shall notify the Engineer at least 40 days prior to needing the server.

The Department-furnished servers shall feature a modular, upgradeable architecture with Intel Xeon Quad Core or greater processors. The servers shall have a minimum of two processors. The servers shall have the following minimum features:

- A minimum clock running speed of 2.33 GHz (both processors)

- 400 MHz front end bus.
- 512KB of integrated L2 ECC cache.
- 4 Gig of error checking and correcting (ECC) RAM (with expansion capacity to 1GB).
- 4 PCI expansion slots.
- Hard disk drive storage capacity with a minimum of three 300GB drives.
- A redundant array of inexpensive disks (RAID) with the chassis, hardware, and interfaces necessary to implement Level 5 RAID storage over three disks.
- The ability to "hot-swap" any single hard disk drive unit without interruption of the server or the LAN.
- RAID storage capacity expandable to 2 TB.
- Ultra-wide SCSI controllers, with a minimum of 160 Mb/s per channel of data through put as needed to accommodate the RAID disk drive units.
- Ultra-narrow SCSI controllers as needed to accommodate SCSI peripheral devices.
- Two (2) 1000 Base-T network interface cards
- A minimum of two (2) Universal Serial Bus (USB) ports (2.0).
- A minimum of one (1) RS-232 serial port.
- Operating system for the server shall be Microsoft Windows Server 2008.
- Rack mountable in standard EIA 19" equipment rack.

13.3. CONSTRUCTION METHODS

Install, configure, test, and demonstrate a fully functional vehicle side-fire detection system. Connect all field hardware and central components to the communication network, and provide all materials specified in these Project Special Provisions. Install all equipment according to the manufacturer's recommendations or as directed by the Engineer.

A. Electrical and Mechanical Requirements

Ground all equipment as called for in the Standard Specifications, these Project Special Provisions, and the Plans.

Install surge protectors on all ungrounded conductors entering the MVD enclosure as described below. House the surge protectors in the MVD cabinet on the pole in a manner approved by the Engineer. The air terminal ground wire must not pass through this cabinet.

B. MVD

Ensure that the MVD can be mounted on new or existing MVD poles or CCTV poles, in a side-fire configuration.

Mount the MVD detector as detailed in the Plans and according to the manufacturer's recommendations. Mount the detector in such a position as to ensure detection of all lanes.

Verify that all detection zones are contained within the specified elevation angle according to the manufacturer's recommendations and that the MVD is capable of fully detecting all vehicles in a minimum of eight lanes or zones. Ensure that the configuration also provides accurate collection of all data types as detailed in this specification.

Provide a detector housing that can be pole-mounted, as indicated in the Plans. Supply a universal mounting bracket that is adjustable on two axes for optimum alignment.

Attach the mounting bracket with approved stainless steel bands that are 0.75 inch wide and 0.025 inch thick, or mount to a concrete structure using two stainless steel expansion bolts of sufficient length and diameter to support 100 pounds.

When installing a detector near metal structures, such as buildings, bridges, or sign supports, mount the sensor and aim it so that the detection zone is not under and does not pass through any structure to avoid distortion and reflection.

Ensure that the detector is factory calibrated to comply with all applicable standards, specifications, and requirements.

Provide an interface to external equipment with a single connector. Ensure that the connector provides power to the unit and allows generation of contact closure output pairs for interface with traffic controller inputs. Ensure that the connector includes serial communication lines for programming, testing, and interfacing with the modem at 9,600 to 115,000 bps baud rate and that it has at least 26 pins. Ensure that the serial port's data format is standard binary non-return to zero (NRZ) modulation with 8-bit data, 1-stop bit, and no parity

Ensure that the lead-in cable is a polyurethane-jacketed cable approved by the Engineer, with polyvinyl chloride (PVC) insulated conductors. The lead-in cable shall have a 300-volt rating and a temperature rating of 200° F. Ensure that the cable is equipped with #20 or #22 American Wire Gauge (AWG) conductors.

Crimp or solder the detector connector pins to the cable conductors. Assemble and test the cable prior to onsite installation and pulling. Cut all wires to their proper length before installation. Do not double back wire to take up slack. Neatly lace wires into cable with nylon lacing or plastic straps, and secure cables with clamps. Provide service loops at all connections.

Perform continuity tests on the detector's stranded conductors using a meter having a minimum input resistance of 20,000 Ω per volt and show that each conductor has a resistance of not more than 16 Ω per 984.25 feet of conductor.

Measure the insulation resistance between isolated conductors and between each conductor, ground, and shield using a meter designed for measuring insulation resistance. The resistance must be infinity. Perform all resistance testing after final termination and cable installation, but prior to the connection of any electronic or field devices.

C. Power Service

Provide 120VAC power service. Comply with the "Electrical Service" requirements of these Project Special Provisions.

D. Surge Suppression

1. Grounding

Connect all grounding points related to the MVD to a single point main grounding electrode as shown in the Plans. A 10-foot grounding electrode shall be installed a minimum of 20 feet away from any additional grounding electrodes and/or ground mounted devices.

This grounding radiant shall consist of one main 10-foot grounding rod located at the structural base of the MVD pole and attached to three additional 10-foot radiant grounding rod placed a minimum of 20 feet away from the main grounding rod. Attach the radiant grounding rod to the main grounding rod with a minimum #4 solid bare copper wire that is exothermically welded at both the main grounding rod and the radiant grounding rod.

2. Load Side Detector Power

Install a transient voltage suppressor (TVSS) at the MVD power source on the supply side. This device shall provide protection between line-to-neutral, line-to-ground, line-to-line and neutral-to-ground.

3. Line Side Detector Power

Install a TVSS in the power line side ahead of all MVD electronic equipment. This installation technique is designed to restrict earth current transients induced within the ground, or directly from the power source, from entering the ITS device through the incoming 120/240-volt power circuit. This device shall provide protection between line to neutral, line to ground, line-to-line and neutral to ground.

4. Load Side Detector Data

Install specialized TVSS devices at the supply and line sides of all low voltage connections to the MVD and its operating subsystems. These connections include, but are not limited to, Category 6 data cables, and low voltage control cables that comply with EIA requirements as detailed in the EIA-232/422/485 standards.

E. Software and Server

Install the software application on the Department-furnished servers at the TRTMC, Division 9 Office, and City of Winston-Salem.

13.4. MEASUREMENT AND PAYMENT

Microwave vehicle detector will be measured and paid for as the actual number of microwave vehicle detector units furnished, installed, and accepted.

No measurement will be made of risers, conduit, enclosures, power supplies, cabling, connectors, pole attachment assemblies, grounding equipment, surge protectors, software, servers, or integration, as these will be considered incidental to furnishing and installing microwave vehicle detectors.

Payment will be made under:

Microwave Vehicle Detector ..... Each

14. SPREAD SPECTRUM WIRELESS RADIO

14.1. DESCRIPTION

Furnish and install a spread spectrum wireless Ethernet radio system with all necessary hardware and signage in accordance with the Plans and Project Special Provisions to provide a data link between field devices. Provide a radio system with a bi-directional, full duplex communications channel between multiple "line-of-sight" antennas to the fiber optic network using license free, spread spectrum technology. Radio systems for digital data-only devices shall operate at the 900 MHz frequency and radio systems for transmission of compressed digital video shall operate at the 2.4 / 5.8 GHz frequency.

Furnish material and workmanship conforming to the *National Electrical Code* (NEC), the *National Electrical Safety Code* (NESC), Underwriter's Laboratories (UL) or a third-party listing agency accredited by the North Carolina Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with all regulations and codes imposed by the owner of affected utility poles.

14.2. MATERIALS

A. 900MHz Wireless Radio System:

Furnish license free 902 – 928 MHz radio modem with antennas, coaxial cable and mounting hardware, and configuration software. Design radio modem to work in "point-to-point", "point-to-multipoint", "multipoint-to-point", and "multipoint-to-multipoint" configurations. Ensure the spread spectrum wireless radio meets the following minimum requirements:

- License free (ISM) Spread Spectrum radio band (902 – 928 MHz)
- Frequency Hopping Technology (Direct Sequence Spread Spectrum Technology is not acceptable)
- Bi-Directional, Full Duplex
- Programmable Radio Frequency (RF) output levels of 1 mW, 10 mW, 100 mW, or 1 Watt
- A minimum of 139 user-selectable radio frequency channels, with 62 available hopping sequences (2 non-overlapping)
- 10/100 BaseT Ethernet interface that complies with IEEE 802.3 and is capable of operating from 1200 bps up to 1.1 Mbps when deployed in the configuration and installed conditions of this project
- RJ-45 connector for Ethernet port
- Maximum of 8 mSec. end-to-end latency
- 16 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit
- Built-in store-and-forward (single radio repeater – back to back radio set-ups are not allowed to accomplish this function)
- 32 Bit encryption
- Receiver Sensitivity of –110 dBm @ 10^-6 BER
- Antenna port: Reverse Polarity - Threaded Normalized Connector-Female (RP TNC-F) antenna connector
- Front Panel LED indicators
  - Power

- Transmit Data
- Receive Data
- Data Port Indicator

- Operating temperature of –40 to +176 degrees F at 0 to 95% Humidity
- Power supply requirements:
  - Wall Adapter: 120 VAC UL/CSA wall cube plug-in module with 12 VDC, 1 Amp, nominal output.
  - Typical current draw of no greater than 355 mA when powered with 12 VDC input, and transmitting 1 Watt of RF output power.
  - Radio Sleep mode with a maximum current draw of <1μA.
- Shelf mounted design not to exceed 9" long x 2" wide x 5" high

Furnish a Radio Frequency Signal Jumper constructed of an RG-58 Coaxial Cable with Reverse Polarity - Threaded Normalized Connector-Male (RP TNC-M) on one end for connection to a radio unit and a Standard N-Type Male Connector on the other end for connection to the lightning arrestor. Provide the jumper in 6 foot lengths.

Ensure that installing the wireless radio system with a fully functional field device (i.e. controller) does not require any field device modifications with regards to hardware or software.

B. 2.4/5.8 GHz Wireless Radio System:

Furnish license free 2.4/5.8 GHz wireless broadband Ethernet radio system with antennas, cabling and mounting hardware, and configuration software. Design radio modem to work in "point-to-point", "point-to-multipoint", "multipoint-to-point", and "multipoint-to-multipoint" configurations. Ensure the wireless broadband Ethernet radio meets the following minimum requirements:

- Frequency – 2.4 GHz ISM & 5.8 GHz ISM, Dynamic Frequency Selection (DFS)
- Wireless Technology – OFDM and DSSS
- Range – greater than 20 Miles (LOS)
- Receiver Sensitivity (dBm) – -70 to -93
- Bandwidth – minimum of 6 Mbps at -94 dBm, capable of 54 Mbps at -74 dBm
- Interface – 10/100 Base-T Ethernet with RJ-45 connector
- Networking – STP, DHCP, NTP, Firewall and NAT, Routing, QOS, VPN, VLAN, SNMP
- Standards Compliance – 802.3, 802.11i, 802.11a
- Security – AES-CCM encryption, 64 bit and 128 bit WEP encryption, WPA, WPA2, , MAC address authentication
- Transmit Power – 23 dB, 600 mW
- Power System – Power-over-Ethernet
  Input: 100-240 AC, 50-60 Hz, Output: 18V, .4A.
- Operating Temperature – -20°F to 140°F
- Operating Humidity – Max 95% non-condensing
- Shelf mounted design

C. Wireless Repeater Standalone Radio System:

B.1 General:

Furnish an operational wireless repeater radio system installed in a NEMA Type 3R enclosure for pole mounting. As a minimum, ensure the Wireless repeater radio meets the specifications provided above.

B.2 Cabinet:

Furnish the cabinet shell constructed from unpainted, natural aluminum. Ensure that all non-aluminum hardware on the cabinet is stainless steel or an approved non-corrosive alternate. Ensure that each exterior cabinet plane surface is constructed of a single sheet of aluminum and is seamless. Provide continuous welds made from the inside wherever possible. On the exterior, provide joints that are smooth and flush. Ensure that no screws, bolts, or rivets protrude to the outside of the cabinet shell.

Ensure that all components are arranged for easy access during servicing.

Provide sufficient size so the installed equipment will not occupy more than 60 percent of the total cabinet volume.

Provide a handle and three point latching mechanism designed to be disassembled using hand tools. Provide a shaft connecting the latching plate to the door handle by passing through the door within a bushing, bearing, or equivalent device. Provide a latching plate at least 1/8 inch thick and that mates securely with the lock bolt. Provide a lock bolt with a flat end (no bevel) and that has at least 1/4 inch of length in contact with the latching plate.

Ensure that the handle and lock are positioned so that the lock does not lie in the path of the rotating handle as the door is unlatched and that the handle points down in the latched position.

Provide a main door opening that encompasses the full frontal area of the cabinet shell. Ensure that the cabinet shell is sturdy and does not exhibit noticeable flexing, bending or distortion under normal conditions, except that a minor amount of flexing is permitted in the main door when the cabinet is open. In such case, the flexing must not result in permanent deformation of the door.

A police panel door is not required for this cabinet.

Provide a roof with a slope from front to back at a minimum ratio of 1 inch drop per 2 feet. Ensure the cabinet is vented at the top and in the door. Supply a cabinet door assembly with a louvered air vent and standard-sized fiberglass air filter.

Provide one equipment shelf in the cabinet that extends the practical width of the cabinet. Ensure that the shelf can be moved up and down within the cabinet. Do not locate permanently mounted equipment in such a way that will restrict access to terminals.

B.3 Cabinet Electrical:

Furnish a cabinet with two 15 Amp, single pole circuit breakers for power distribution. Ensure one 15 Amp auxiliary breaker provides the electrical circuit to accommodate a thermostatically controlled cabinet exhaust fan, door activated fluorescent light, and one GFCI convenience receptacle.

Ensure the second 15 Amp equipment breaker provides the electrical circuit to accommodate the electrical equipment installed in the cabinet with a minimum of two duplex receptacles.

Provide a two-stage power line surge protector between the electrical equipment receptacles and the 15 Amp equipment breaker. Ensure a maximum continuous current of at least 10A at 120V. Ensure that the device can withstand a minimum of 20 peak surge current occurrences at 20,000A for an 8x20 microsecond waveform. Provide a maximum clamp voltage of 280V at 20,000A with a nominal series inductance of 200µh. Ensure that the voltage does not exceed 280V. Provide devices that comply with the following:

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

Ensure the two-stage power line surge protector will allow connection of a radio frequency interference filter between the two stages of the device. Ensure the radio frequency interference filter minimizes interference generated in the cabinet in both the broadcast and aircraft frequencies. Ensure the filter(s) provide attenuation of at least 50 decibels over a frequency range of 200 kilohertz to 75 megahertz. Furnish a filter that is hermetically sealed in an insulated metal case. Ensure the filter is rated at least at the rated current of the main circuit breaker, 125-volts, 60Hz.

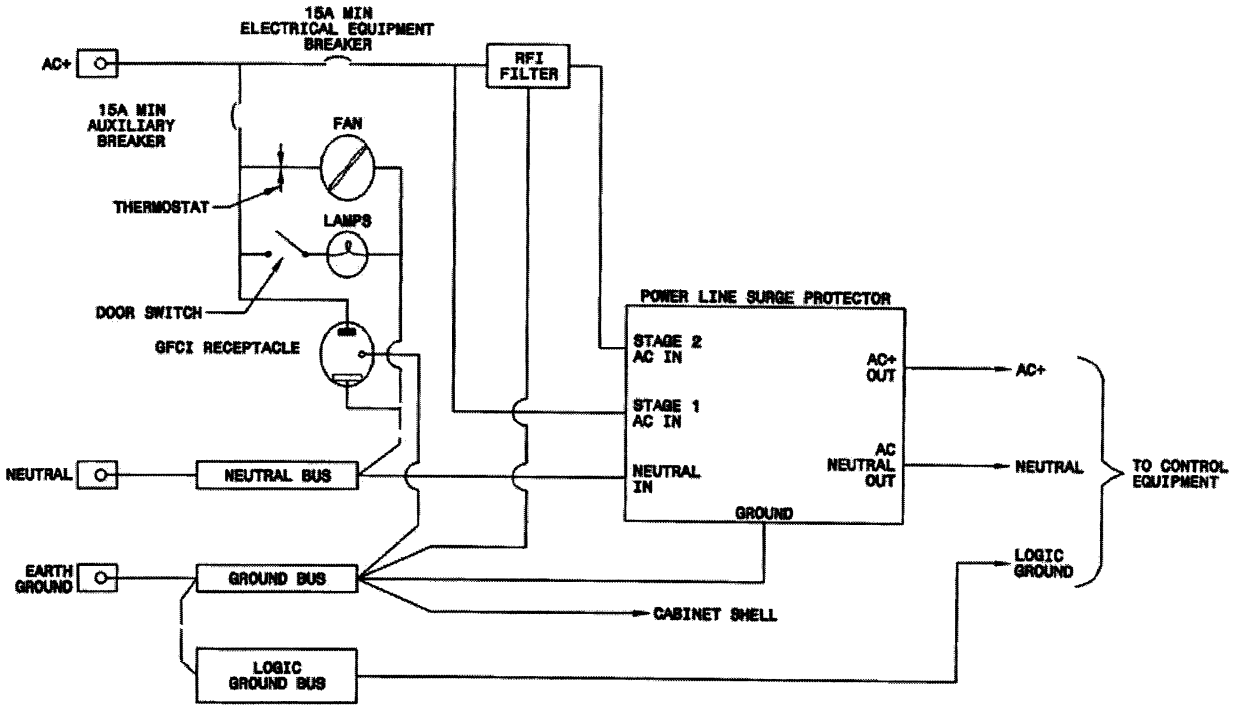
Furnish a fluorescent fixture with lamps mounted above the shelf to light the equipment area.

Fasten all wiring and harness supports to the cabinet with screws or other removable mechanical means. Do not use adhesives.

Do not locate terminals on the underside of the shelf or at other places where they are not readily visible and accessible, or where they may be a hazard to personnel. Provide a clear plastic guard for exposed 120-volt AC terminals on the power panel.

Provide a neutral that is not connected to the earth ground or the logic ground anywhere within the cabinet. Ensure that the earth ground bus and the neutral ground bus each have ten compression type terminals each of which can accommodate wires ranging from number 14 through number 4.

Furnish a cabinet wiring schematic to be placed in the cabinet. Reference the cabinet wiring schematic below for additional details:



D. Software:

Furnish units with a Window Based™ software program that uses a GUI (Graphical User Interface) to provide "remote programming, radio configuration, remote maintenance, diagnostics and spectrum analyzer" features. Ensure the software will operate on Microsoft ® Windows Operating Platforms: Windows XP at a minimum or latest available version. Provide configuration software that can be upgraded in the future at no additional charge.

Ensure the radio modem is configurable from a single location (i.e. master radio location) via supplied software (no extra cost). Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal controllers, including 2070 controllers containing custom software written specifically for the North Carolina Department of Transportation. Ensure the supplied software contains pre-written drivers for industry standard radar packages, Dynamic Message Sign controllers, and Closed Circuit Television camera controllers that will be utilized on this project.

E. Directional Antenna (Yagi):

For 900 MHz radio systems, furnish a 8.5 dBd Gain or 13 dBd Gain directional antenna that will allow the system to function as designed.

For 2.4 / 5.8 GHz radio systems, furnish a 13 dBd Gain directional antenna that will allow the system to function as designed.

All antennas furnished shall meet the following minimum specifications:

Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
Welded construction	

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1.5" Nominal Pipe Size (approximately 2" OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

F. Omni Directional Antenna:

For 900 MHz radio systems, furnish a 3 dBd Gain or 6 dBd Gain omni directional antenna that will allow the system to function as designed.

For 2.4 / 5.8 GHz radio systems, furnish a 7.5 dBd Gain omni directional antenna that will allow the system to function as designed.

All antennas furnished shall meet the following minimum specifications:

Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5 inch radial ice)	100 mph
Allows for Vertical or Horizontal polarization	
Minimum separation distance from persons installing and using an active device	9"
Minimum separation distance from other RF sources including radios and antennas	6.5'
Welded construction	

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1.5" Nominal Pipe Size (approximately 2" OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

G. Antenna Mounting Hardware Kit:

Furnish an antenna mounting kit to support the antenna when attached to a metal pole, mast arm, or wood pole. Furnish PELCO – "Antenna Mount, Cable Astro-Brac for Yagi Antenna" or an approved equivalent.

Ensure the Antenna Mounting Hardware Kit includes a minimum of a 96" galvanized cable with stainless steel bolt with a nut and lock washer assembly on each end. Ensure the pole base plate accepts a 1 ½" NPT aluminum pipe, and provides a surface that is a minimum of 6 ¾ inch long by 4

¼" to provide contact with the pole. Ensure the pole base plate is designed to allow both ends of the 96" galvanized cable to be secured and tightened to the base plate. Proved a 90 degree elbow with internal treads on both ends to accommodate 1 ½" NPT aluminum pipes. Provide a 1 ½" * 18" long aluminum pipe threaded on both ends and a 1 ½" * 24" aluminum pipe threaded on 1 end with an end cap.

PELCO PART #'s	DESCRIPTION	QUANTITY
AB-3034-96-PNC	Astro-Brac Clamp Kit, 1 ½" NPS, Galv Cable, Alum	1
AB-0260	TUBE CAP, PLASTIC	1
SE-0436-18	NIPPLE, 1 ½" x 18" LONG, ALUM, THREADED ON BOTH ENDS	1
SE-0457-DS-PNC	ELL, SERRATED, 1 ½", DOUBLE SET SCREW, DIE CAST ALUM	1
SE-0326-24	SUPPORT TUBE, SCH 40, 1 ½" NPS x 24" LONG, ALUM, THREADED ON ONE END	1

H. Coaxial Cable:

Furnish 400 Series coaxial cable to provide a link between the antenna and the lightning arrestor that meets the following minimum specifications:

Attenuation (dB per 100 feet) @ 900 MHz	3.9 dB
Power Rating @ 900 MHz	0.58 kW
Center Conductor	0.108" Copper Clad Aluminum
Dielectric: Cellular PE	0.285"
Shield	Aluminum Tape – 0.291" Tinned Copper Braid – 0.320"
Jacket	Black UV protected polyethylene
Bend Radius	1" with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance per foot	23.9 pf/ft
End Connectors	Standard N-Type Male Connectors on both ends

I. Standard N-Type Male Connector:

Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series coaxial cable and utilize a crimping method to secure the connector to the coaxial cable. Furnish a connector that meets the following minimum specifications:

- Center Contact: Gold Plated Beryllium Copper-(spring loaded – Non-solder)
- Outer Contact: Silver Plated Brass
- Body: Silver Plated Brass
- Crimp Sleeve: Silver Plated Copper
- Dielectric: Teflon PTFE
- Water Proofing Sleeve: Adhesive Lined Polyolefin – Heat Shrink
- Attachment Size: Crimp Size 0.429" (minimum) hex

Electrical Properties:

- Impedance: 50 ohms
- Working Voltage: 1000 vrms (max)
- Insertion loss: 0.1 x √ Fghz
- VSWR. 1.25:1 (max) up to 3GHz

Provide instructions on properly installing the connector.

J. Coaxial Cable Shield Grounding and Weatherproofing Kits:

Furnish a Coaxial Cable Shield Grounding Kit containing components that will adequately bond and ground the cable shield to the pole ground. Ensure the grounding kit complies with MIL-STD-188-124A Specifications "Military Standard for Grounding, Bonding and Shielding" for coaxial cable and protects the cable from lightning currents in excess of 200kA. Ensure each kit is supplied, as a minimum, with the following:

- Preformed Strap: 24 Gauge copper strap that is a minimum of 1 5/8 inch long and is sized to mate with the 400 series coaxial cable
- Tensioning Hardware: Copper nuts and lock washers
- Grounding Lead Cable: #6 AWG, stranded, insulated copper wire
- Instructions on properly installing the shield grounding system

Furnish a Weatherproofing Kit containing components that will protect the coaxial cable shield grounding system against the ingress of moisture and prevent vibrations from loosening the connections. Ensure the weatherproofing kit is supplied, as a minimum, with the following:

- Butyl Mastic Tape: 3 3/4 inches wide by 24 inches long (approximately)
- Electrical Tape: 2 inch wide by 20 inches long (approximately)
- Instructions on properly installing the weatherproofing system

K. Lightning Arrestor:

Furnish a lightning arrestor installed in line between each antenna and its designated radio modem inside the equipment cabinet. Furnish a Polyphaser Model # DSXL-BF lightning arrestor or an approved equivalent that meets the following minimum specifications:

- Filter Type – DC Block (None gas tube design)
- Surge: 20kA, 800MHz to 2.0GHz ≤ 1.1 : 1 VSWR
  18kA, 800MHz to 2.3GHz ≤ 1.1 : 1 VSWR
  700MHz to 2.7GHz ≤ 1.2 : 1 VSWR
- Insertion Loss: ≤0.1 dB over frequency range
- Max Power: 500 w @ 920MHz (750 W @ at 122° F)
- RF Power: 300 Watts
- Let Through Voltage: ≤+/- 3 Volts for 3kA @ 8/20 µs Waveform
- Throughput energy: ≤ 0.5 µJ for 3kA @ 8/20 µs Waveform
- Temperature: -40 to 185° F Storage/Operating 122° F
- Vibration: 1G at 5 Hz up to 100Hz
- Unit Impedance: 50Ω
- VSWR: 1.1:1
- Frequency Range: 800 MHz to 2200 MHz

- Multistrike capability
- Low strike throughput energy
- Flange mount and bulkhead mount options
- Standard N-Type Female Connector on both the surge side and protected side connectors

L. Coaxial Cable – Power Divider (Splitter):

Furnish a coaxial cable – power divider for repeater radio sites. Ensure the power divider accommodates a single primary input RF source and divides/splits the signal (power) equally between two output ports. Furnish a Telewave Inc., Model ANT-PD29 power divider or an approved equivalent that meets the following minimum specifications.

Power Division	2 – Way
Frequency	900 – 1100 MHz
Insertion Loss	0.22 dB
Impedance	50 Ohm
VSWR ref. to 50 Ohm (max)	1.3:1
Max. Input Power	500 Watts
Connectors	Standard N-Type Female
Dimension	2.5"W x 5"L
Weight	1.5 lbs (approximately)

M. Disconnect Switch:

Furnish a double pole, single throw snap switch in a weatherproof outlet box with cover, suitable for use in wet locations. Ensure outlet box and cover supports a lockout tag device. Ensure outlet box includes one ½-inch hole in back of box. Furnish mounting hardware, sealing gaskets and lockout tag. (NOTE: On NCDOT owned poles the "Disconnect Switch" can be omitted.)

N. Warning Signs(s) and Decal(s):

Furnish "RF Warning Sign" and "Decal" at locations called for in the Plans. Furnish mounting hardware to secure the Sign to either metal or wood poles. Secure the sign to the pole using 'Band-It' brackets or a method approved by the engineer. (NOTE: On NCDOT owned poles the "RF Warning Sign" and "Decal" can be omitted.)

14.3. CONSTRUCTION METHODS

A. General:

Perform a radio path Site Survey test before installing any equipment. All radio path site surveys shall be completed during full foliage conditions. Ensure the test evaluates the Signal Strength (dBm), Fade Margin (dB), Signal-to-Noise Ratio, Data Integrity (poll test), and a complete frequency spectrum scan. Ensure the radio path site survey test is performed using the supplied brand of radio equipment to be deployed. During the initial radio path signal strength test it may be determined that a repeater station may be necessary to complete the intended link. Provide the test results to the Engineer for review and approval. Submit copies of the test results and colored copies

of the frequency spectrum scan along with an electronic copy of this information. The Engineer will approve final locations of antennas and any necessary repeater stations. Install a coaxial cable – power divider, antenna splitter cable and additional antenna at locations where it is determined that a dual antenna configuration is necessary to accommodate communications in multiple directions.

Install the antenna in such a manner that avoids conflicts with other utilities (separation distances in accordance with the guidelines of the NESC) and as specified in the antenna manufacturer's recommendations. Secure the antenna mounting hardware to the pole and route the coaxial cable such that no strain is placed on the N-Type Male coaxial connectors. On wood pole installations, bond the antenna mounting hardware to the pole ground using # 6 AWG bare copper wire using split bolt or compression type fitting.

Install the coaxial cable shield grounding system by carefully removing the outer jacket of the coaxial cable without damaging the cable shield. Install the shield grounding system following the cable manufacturer's recommendations. Install and weatherproof the connection using the appropriate weatherproofing materials and following the manufacturer's recommendations. On wood poles, secure the #6 AWG grounding lead cable to the pole ground using split bolt or compression type fitting or an Engineer approved method. On metal poles, secure the #6 AWG grounding lead cable to the pole using an Engineer approved method.

Do not exceed the 1-inch bend radius of the coaxial cable as it traverses from the cabinet to the antenna assembly. Connect the lightning arrestor to the coaxial cable in the equipment cabinet. Properly ground and secure the arrestor in the cabinet. Permanently label all cables entering the cabinet. Ensure the power supply for the radio system is **NOT** connected to the GFCI receptacle circuit located in the cabinet. Place a copy of all manufacturer equipment specifications and instruction and maintenance manuals in the equipment cabinet.

At certain locations it may be necessary to integrate the radio system with a fiber optic system. Follow the details shown in the fiber optic splice plans.

B. Repeater Cabinets:

Do not obstruct the sight distance of vehicles when locating and installing cabinets.

Install the pole-mounted cabinet approximately five feet from the ground line to the top of the cabinet. Secure the cabinet to the pole using 'Band-It' brackets or a method approved by the Engineer. Leave the RS-232 data interface cable in the cabinet.

C. Disconnect Switch:

At all locations, where the antenna is mounted on a joint use pole, install a double pole, snap switch to remove power from the spread spectrum wireless radio system. Do not mount weatherproof box on the field equipment cabinet door. Drill a hole in the side of the field equipment cabinet. Mount the outlet box over the hole using a ½-inch chase nipple and bushings. Ensure sealing gaskets are in place and no water can enter the cabinet. Securely mount the weatherproof outlet box with additional mounting screws. Bond the outlet box to the equipment ground bus. See Plans for approximate mounting height. Run the power supply cord of the spread spectrum radio unit into the outlet box and connect to switch. Securely attach power supply cord to equipment rack. Install disconnect switch with lockout tag cover. (NOTE. If the antenna is mounted on an NCDOT owned pole the "Disconnect Switch" can be omitted.)

Do not install power supply for the radio in a GFCI protected outlet.

D. Warning Sign(s) and Decal(s):

At all locations, where the antenna is mounted on a joint use pole, secure a Warning Sign to pole. Mount Warning Sign(s) at locations called for on the Plans. Ensure there are no conflicts between the warning sign and surrounding utilities. Mount Warning Sign to be easily viewed. Do not mount Warning Sign under pole grounds or conduit. (NOTE: If the antenna is mounted on an NCDOT owned pole the "RF Warning Sign" can be omitted.)

Clean and remove any dirt or oil on traffic cabinet before placing Decal. Place decal adjacent to the disconnect switch located on the outside of traffic cabinet. (NOTE: If the antenna is mounted on an NCDOT owned pole the "Decal" can be omitted.)

14.4. WARRANTY

Provide a minimum two-year warranty with each radio and antenna assembly to ensure the products are free of manufacturing defects in material and workmanship. The warranty commences on the date the radio system is accepted by the Engineer.

14.5. MEASURMENT AND PAYMENT

(___) wireless radio system will be measured and paid for as the actual number of wireless radio systems furnished, installed and accepted. A system is defined as a point-to-point or point-to-multipoint configuration of wireless radios that are integrated with the fiber optic network.

This item includes the appropriate sized antennas, radios, power supplies and injectors, disconnect/snap switches, signs, decals, interface cabling, coaxial cabling, lightning arrestors, radio frequency signal jumpers, coaxial cable power dividers (Splitter), coaxial cable connectors, coaxial cable shield grounding systems with weatherproofing, and labeling. Any integration between the wireless radio system and a fiber optic network, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties, will be incidental.

(___) wireless repeater standalone radio system will be measured and paid for as the actual number of wireless repeater standalone radio systems furnished, installed and accepted.

This item includes the appropriate sized NEMA 3R cabinet, conduit, vertical risers, antennas, radios, power supplies and injectors, disconnect/snap switch, signs, decals, interface cabling, coaxial cabling, lightning arrestors, radio frequency signal jumpers, coaxial cable power dividers (Splitter), coaxial cable connectors, coaxial cable shield grounding systems with weatherproofing, and labeling. Any integration, installation materials and configuration software necessary to complete this work, including the radio path Site Survey test and warranties, will be incidental.

Payment will be made under:

900MHz Wireless Radio System ..... Each
2.4/5.8 GHz Wireless Radio System ..... Each
900MHz Wireless Repeater Standalone Radio System ..... Each
2.4/5.8 GHz Wireless Repeater Standalone Radio System ..... Each

Revised 4-6-11

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15. CCTV FIELD EQUIPMENT

15.1. DESCRIPTION

Furnish and install CCTV field equipment described in these Project Special Provisions. Furnish equipment that is compatible, interoperable, and completely interchangeable with existing Pelco Spectra IV high-performance dome equipment currently in use by NCDOT in this Region. Ensure that the equipment is fully compatible with all features of the existing video matrix switch and existing *VideoPro* CCTV control and management software currently in use by the NCDOT Division 9 region.

15.2. MATERIALS

A. General:

Furnish and install new CCTV camera assemblies at the locations shown on the Plans. Each assembly consists of the following:

- One Dome CCTV camera that contains in a single enclosed unit the following functionality and accessories:
  - CCTV color digital signal processing camera unit with zoom lens, filter, control circuit, and accessories
  - Motorized pan, tilt, and zoom
  - Pole-mount camera attachment assembly
  - All necessary cable, connectors and incidental hardware to make a complete and operable system
- A lightning arrestor installed in-line between the CCTV camera and the equipment cabinet components.
- A NEMA Type 4 enclosure constructed of aluminum with a clear acrylic dome or approved equal Camera Unit housing.

B. Camera and Lens

1. Cameras

Furnish new charged-coupled device (CCD) color cameras. Furnish cameras with automatic gain control (AGC) for clear images in varying light levels. The camera must meet the following minimum requirements:

- Video signal format: NTSC composite color video output, 1 volt peak to peak
- Automatic Gain Control (AGC): 0-20 dB, peak-average adjustable
- Automatic focus: Automatic with manual override
- White balance: Automatic through the lens with manual override

- Electronic-Shutter: dip-switch selectable electronic shutter with speed range from 1/60 of a second (off) to 1/30,000th of a second
- Overexposure protection: The camera must have built-in circuitry or a protection device to prevent any damage to the camera when pointed at strong light sources, including the sun
- Sensitivity: 1.5 lux at 90% scene reflectance
- Signal to noise ratio: Greater than 48-dB
- Video output Connection: 1-volt peak to peak, 75 ohms terminated, BNC connector
- Power: 24 VAC or less

2. Zoom Lens

Furnish each camera with a motorized zoom lens that is high performance integrated dome system or approved equivalent with automatic iris control with manual override and neutral density spot filter. Furnish lenses that meet the following optical specifications:

- Focal length: 0.16" – 3.45", 35X optical zoom, and 12X electronic zoom
- Preset positioning: 64 Presets

The lens must be capable of both automatic and remote manual control iris and focus override operation. The lens must be equipped for remote control of zoom and focus, including automatic movement to any of the preset zoom and focus positions. Mechanical or electrical means must be provided to protect the motors from overrunning in extreme positions. The operating voltages of the lens must be compatible with the outputs of the camera control.

C. Camera Housing

Furnish new dome style enclosure for the CCTV assemblies. Equip each housing with mounting assembly for attachment to the CCTV camera pole. The enclosures must be equipped with a sunshield and be fabricated from corrosion resistant aluminum and finished in a neutral color of weather resistant enamel. The enclosure must meet or exceed NEMA 4X ratings. The viewing area of the enclosure must be tempered glass.

D. Pan and Tilt Unit

Equip each new dome style assembly with a pan and tilt unit. The pan and tilt unit must be integral to the high performance integrated dome system. The pan and tilt unit must be rated for outdoor operation, provide dynamic braking for instantaneous stopping, prevent drift, and have minimum backlash. The pan and tilt units must meet or exceed the following specifications:

- Pan: continuous 360 Degrees
- Tilt: up/down 180 degrees minimum
- Input voltage: 24 VAC 50/60Hz
- Motors: Two-phase induction type, continuous duty, instantaneous reversing

- Preset Positioning: 64 PTZ presets per camera

E. Control Receiver/Driver

Provide each new camera unit with a control receiver/driver that is integral to the CCTV dome assembly. The control receiver/driver will receive serial asynchronous data initiated from a camera control unit, decode the command data, perform error checking, and drive the pan/tilt unit, camera controls, and motorized lens. As a minimum, the control receiver/drivers must provide the following functions:

- Zoom in/out
- Automatic focus with manual override
- Tilt up/down
- Automatic iris with manual override
- Pan right/left
- Minimum 64 preset positions for pan, tilt, and zoom

In addition, each control receiver/driver must accept status information from the pan/tilt unit and motorized lens for preset positioning of those components. The control receiver/driver will relay pan, tilt, zoom, and focus positions from the field to the remote camera control unit. The control receiver/driver must accept "goto" preset commands from the camera control unit, decode the command data, perform error checking, and drive the pan/tilt and motorized zoom lens to the correct preset position. The preset commands from the camera control unit will consist of unique values for the desired pan, tilt, zoom, and focus positions.

F. CCTV Camera Attachment to Pole

At locations shown in the Plans where new CCTV cameras are to be installed on new CCTV poles, furnish an attachment assembly for the CCTV camera unit. Use stainless steel banding approved by the Engineer. Submit shop drawings for review and approval by the Engineer prior to installation. At the CCTV-2 location, attach the CCTV to the DMS walkway as shown in the Plans.

Furnish CCTV attachments that allow for the removal and replacement of the CCTV enclosure as well as providing a weatherproof, weather tight, seal that does not allow moisture to enter the enclosure.

Furnish a CCTV Camera Attachment Assembly that is able to withstand wind loading at the maximum wind speed and gust factor called for in these Special Provisions and can support a minimum camera unit dead load of 45 pounds (20.4 kg).

G. Surge Suppression

Protect all equipment at the top of the pole grounded metal oxide varistors connecting each power conductor to ground.

Protect coaxial cable from each camera by a surge protector at each end of the cable.

H. Field Video CODEC Unit

Furnish a field-hardened video encoder designed for unheated/uncooled "outdoor" applications such as roadside control cabinets. The video encoder shall be installed in equipment cabinet and shall allow for the encoding and transmission of analog NTSC video signals from new CCTV units that will be provided under this Project.

Furnish a shelf-mountable, field-hardened video encoder to convert analog NTSC video signals into two digital video streams that can be transported over Ethernet. The video encoder shall allow for the simultaneous encoding and transmission of the two digital video streams - one in MPEG-2 or MPEG-4 format (high-resolution) and one in MPEG-4 format (low-resolution). High resolution streams shall allow video bit rates from 1 to 4 Mbps and the low resolution stream shall allow video bit rates from 64 kbps to 2 Mbps. The Contractor shall initially configure these formats for 2 Mbps and 384kbps, respectively. The video encoder shall also transmit pan-tilt-zoom control data from all CCTV control points to the CCTV camera via a serial connection to the CCTV camera resident on the CODEC.

The video encoder shall support the following digital transport standards at a minimum: RTP/IP, UDP/IP, TCP/IP, and unicast/multicast IP. The Contractor shall initially use UDP/IP for video transport and TCP/IP for camera control transport unless otherwise approved by the Engineer.

The video shall support resolutions of CIF (352 (H) x 240 (V)), 1/2 D1 (352 (H) x 480 (V)), and D1 (720 (H) x 480 (V)) at a minimum. The video encoder units shall provide a display showing diagnostic data such as data rate, quality level, frame rate, and video status on the front panel. All supporting user interface software shall be provided with each encoder unit.

The video encoder shall be equipped with at least one NTSC video input, two RS-232/422 serial ports and one 10/100BaseTX Ethernet port. The 10/100BaseTX port shall support half-duplex or full-duplex and provide auto negotiation, and shall be initially configured for full-duplex.

The video encoder shall be remotely manageable using standard network applications such as telnet, SNMP monitors, and/or web interface administration. The video encoder shall be equipped with LED or other approved indicators for the following functions:

- Power
- Link
- Activity

1. Electrical Requirements

The video encoder shall operate from 115 VAC (+/-10%) power at 60 Hz. The Contractor shall furnish any external step down transformers, power converters, and/or regulation equipment needed to operate the video encoder.

2. Physical and Environmental Requirements

The video encoder enclosure shall be constructed of high-strength galvanized steel. For Contractor-supplied cameras, the video encoder shall be installed in equipment cabinets and secured to the cabinet in a manner that is approved by the Engineer. The video encoder enclosure, including adapters/connectors, shall fit neatly within the confines of the equipment cabinet. All necessary mounting hardware shall be provided by the Contractor.

The video encoder shall meet or exceed NEMA TS-2 requirements for shock, temperature, humidity, and vibration. The video encoder shall operate at ambient temperatures from -40° to 185° F (-40° to 85° C) and ambient relative humidity from 0% to 90% (non-condensing). No cooling airflow shall be required.

3. Communication Interface Requirements

The video encoder shall comply with the 10/100BaseTX standard and have at least one standard RJ-45 interface. The 10/100BaseTX port shall operate as half-duplex or full-duplex and provide auto negotiation.

The video encoder shall have at least one video input that supports composite NTSC format compatible with the CCTV video interface cables. Interconnection with the NTSC video input shall be made with a surge protector that provides an external electrical ground bonding capability and does not require an electrical receptacle. The CCTV coaxial surge protector shall provide a clamping voltage no greater than 30 volts.

The video encoder shall have at least two serial ports – one for pan-tilt-zoom camera control and the other for local maintenance or data transport. The two serial ports shall support RS-232 and RS-422 data transmission and shall be transparent to the central system using TCP/IP network access methods. Interconnection with camera control receivers with or without adapters or converters (i.e. RS-422/232 for compatibility with CCTVs) shall provide opto-isolated surge suppression. The optical isolation shall provide an isolation of no greater than 2000 VAC for data signals and ground.

4. Cables and Connectors

The Contractor shall furnish and install all cables and connectors necessary for video encoder installation. This shall include at a minimum CAT 5E cables with RJ-45 connectors to connect the Video Encoder to the Field Ethernet Switch in the equipment cabinet or traffic controller cabinet and standard serial data cables to connect the Video Encoder to the CCTV camera for pan-tilt-zoom functions and local configuration administration.

15.3. CONSTRUCTION METHODS

A. General

Mount CCTV camera units at a height sufficient to adequately see traffic in all directions and as approved by the Engineer. The maximum attachment height is 35 feet above ground level.

Mount the CCTV camera units such that a minimum 5 feet of clearance is maintained between the camera and the top of the pole.

Obtain approval of the camera locations and orientation from the Engineer prior to installing the CCTV camera assemblies.

Mount CCTV cameras on the side of poles nearest intended field of view Avoid occluding the view with the pole.

B. Electrical and Mechanical Requirements

Ground all equipment as called for in the Standard Specifications, these Special Provisions, and the Plans.

Install surge protectors on all ungrounded conductors entering the CCTV enclosure. House the protectors in a small, ventilated weatherproof cabinet attached near the CCTV attachment point in a manner approved by the Engineer.

C. Field Video CODEC Unit

At locations where the field Video CODEC unit is called for installation into new equipment cabinet, integrate field CODEC with Ethernet switch, CCTV assembly, CCTV test panel, power distribution assembly, and surge protection. Ground and provide electrical transient protection to the CODEC in accord with these Project Special Provisions and the CODEC manufactures requirements. Prior to delivery of the Video Encoder, the Contractor shall provide a factory acceptance certificate demonstrating that the Video Encoder has been successfully bench tested by the manufacturer or an independently-certified test lab.

15.4. MEASUREMENT AND PAYMENT

CCTV camera assembly will be measured and paid as the actual number of CCTV camera assemblies furnished, installed, and accepted.

No separate measurement will be made for cabling, connectors, CCTV camera attachment assemblies, risers, conduit, condulets, grounding equipment, surge protectors, CCTV control software, or any other equipment or labor required to install the CCTV assembly. No separate payment will be made for coaxial cable. Coaxial cable, furnished and installed in the quantities required, will be incidental to the "CCTV Assembly" pay item.

Field Video CODEC Unit will be measured and paid for as the actual number of units, furnished, installed, integrated, and accepted.

All cabling, integration, and configuration required to install the field video CODEC unit shall be incidental and not be paid for separately.

Payment will be made under:

CCTV Camera Assembly ..... Each
Field Video Codec Unit ..... Each

16. FIELD EQUIPMENT CABINET

16.1. DESCRIPTION

Furnish and install new field equipment cabinets at locations shown in the Plans.

16.2. MATERIALS

A. General

Conform to CALTRANS *Traffic Signal Control Equipment Specifications* except as required herein.

Furnish 336 pole mounted cabinets to house ITS device control and transmission equipment. The cabinets must consist of a cabinet housing, 19-inch EIA mounting cage, and power distribution assembly (PDA #3 as described in the CALTRANS TSCES).

The cabinet housing must conform to sections 6.2.2 (Housing Construction), 6.2.3 (Door Latches and Locks), 6.2.4 (Housing Ventilation), and 6.2.5 (Hinges and Door Catches) of the CALTRANS TSCES. Do not equip the cabinet housings with a police panel.

The cabinet cage must conform to section 6.3 of the CALTRANS TSCES.

Terminal blocks on the PDA #3 Assembly have internal wiring for the Model 200 switch pack sockets. Do not use terminal blocks on PDA #3 as power terminals for cabinet devices. Do not furnish cabinet with "Input Panels" described in section 6.4.7 1 of the TSCES. Do furnish cabinet with "Service Panels" as described in section 6.4.7.1 of the TSCES and as depicted on drawing TSCES-9 in the TSCES. Use service panel #2.

Furnish terminal blocks for power for cabinet CCTV and communications devices as needed to accommodate the number of devices in the cabinet.

Do not furnish cabinets with C1, C5, or C6 harness, input file, output file, monitor units, model 208 unit, model 430 unit, or switch packs.

Furnish all conduits, shelving, mounting adapters, and other equipment as necessary to route cabling, mount equipment, and terminate conduit in equipment cabinet.

B. Shelf Drawer

Provide a pull out, hinged-top drawer, having sliding tracks, with lockout and quick disconnect feature, such as a Vent-Rak Retractable Writing Shelf, #D-4090-13 or equivalent in the equipment cabinet. Furnish a pullout drawer that extends a minimum of 14 inches that is capable of being lifted to gain access to the interior of the drawer. Minimum interior dimensions of the drawer are to be 1 inch high, 13 inches deep, and 16 inches wide. Provide drawers capable of supporting a 40-pound device or component when fully extended.

C. Cabinet Light

Each cabinet must include two (2) fluorescent lighting fixtures (one front, one back) mounted horizontally inside the top portion of the cabinet. The fixtures must include a cool white lamp, and must be operated by normal power factor UL-listed ballast. A door-actuated switch must be installed to turn on the applicable cabinet light when the front door or back door is opened. The lights must be mounted not to interfere with the upper door stay.

D. Surge Protection for System Equipment

Each cabinet must be provided with devices to protect the control and communications equipment from electrical surges and over voltages as described below.

1. Main AC Power Input

Each cabinet must be provided with a hybrid-type, power line surge protection device mounted inside the power distribution assembly. The protector must be installed between the applied line voltage and earth ground. The surge protector must be capable of reducing the effect of lightning transient voltages applied to the AC line. The protector must be mounted inside the Power Distribution Assembly housing facing the rear of the cabinet. The protector must include the following features and functions:

- Maximum AC line voltage: 140 VAC.
- Twenty pulses of peak current, each of which must rise in 8 microseconds and fall in 20 microseconds to ½ the peak: 20000 Amperes.
- The protector must be provided with the following terminals:
  - Main Line (AC Line first stage terminal).
  - Main Neutral (AC Neutral input terminal).
  - Equipment Line Out (AC line second state output terminal, 19 amps).
  - Equipment Neutral Out (Neutral terminal to protected equipment).
  - GND (Earth connection).
- The Main AC line in and the Equipment Line out terminals must be separated by a 200 Microhenry (minimum) inductor rated to handle 10 AMP AC Service.
- The first stage clamp must be between Main Line and Ground terminals.
- The second stage clamp must be between Equipment Line Out and Equipment Neutral.
- The protector for the first and second stage clamp must have an MOV or similar solid state device rated at 20 KA and must be of a completely solid state design (i.e., no gas discharge tubes allowed).
- The Main Neutral and Equipment Neutral Out must be connected together internally and must have an MOV similar solid state device or gas discharge tube rated at 20 KA between Main Neutral and Ground terminals.
- Peak Clamp Voltage: 350 volts at 20 KA. (Voltage measured between Equipment Line Out and Equipment Neutral Out terminals. Current applied between Main Line and Ground Terminals with Ground and Main Neutral terminals externally tied together).
- Voltage must never exceed 350 volts.
- The Protector must be epoxy-encapsulated in a flame-retardant material.
- Continuous service current: 10 Amps at 120 VAC RMS.
- The Equipment Line Out must provide power to cabinet control and communications equipment and to the 24V power supply.

2. Ground Bus

Provide a neutral bus that is not connected to the earth ground or the logic ground anywhere within the cabinet. Ensure that the earth ground bus and the neutral ground bus each have ten

compression type terminals, each of which can accommodate wires ranging from number 14 through number 4 AWG.

3. Uninterruptible Power Supply (UPS)

Furnish and install one rack mounted UPS in each new cabinet that meet the following minimum specifications:

- Output
  - Output Power Capacity: 480 Watts / 750 VA
  - Max Configurable Power: 480 Watts / 750 VA
  - Nominal Output Voltage: 120V
  - Output Voltage Distortion: Less than 5% at full load
  - Output Frequency (sync to mains) : 57 - 63 Hz for 60 Hz nominal
  - Crest Factor: up to 5:1
  - Waveform Type: Sine wave
  - Output Connections: (4) NEMA 5-15R
- Input
  - Nominal Input Voltage: 120V
  - Input Frequency: 50/60 Hz +/- 3 Hz (auto sensing)
  - Input Connections: NEMA 5-15P
  - Cord Length: 6 feet
  - Input voltage range for main operations: 82 - 144V
  - Input voltage adjustable range for mains operation: 75 -154 V
- Battery Type
  - Maintenance-free sealed Lead-Acid battery with suspended electrolyte, leak-proof.
  - Typical recharge time: 2 hours
- Communications & Management
  - Interface Port(s) : DB-9 RS-232, USB
  - Control panel: LED status display with load and battery bar-graphs
- Surge Protection and Filtering
  - Surge energy rating: 480 Joules
- Environmental
  - Operating Environment: 32 - 104 °F
  - Operating Relative Humidity: 0 - 95%
  - Storage Temperature: 5 - 113 °F
  - Storage Relative Humidity: 0 - 95%
- Conformance
  - Regulatory Approvals: FCC Part 15 Class A,UL 1778

16.3. CONSTRUCTION METHODS

For each field equipment cabinet installation, use stainless steel banding or other method approved by the Engineer to fasten cabinet to pole. Install field equipment cabinets so that the height to the middle of the enclosure is 4 feet from ground level. No risers shall enter the top or sides of the equipment cabinet.

Install all conduits, condulets, and attachments to equipment cabinets in a manner that preserves the minimum bending radius of cables and creates water proof connections and seals.

Install a UPS in each cabinet and power all CCTV cameras from the UPS.

16.4. MEASUREMENT AND PAYMENT

Field equipment cabinet will be measured and paid for as the actual number of pole mounted equipment cabinets furnished, installed, integrated, and accepted.

No payment will be made for the UPS, cabling, connectors, cabinet attachment assemblies, conduit, condulets, risers, grounding equipment, surge protectors, or any other equipment or labor required to install the field equipment cabinet and integrate the cabinets with the ITS device equipment.

Payment will be made under:

Field Equipment Cabinet ..... Each

17. LOCAL AREA NETWORK EQUIPMENT

17.1. DESCRIPTION

A. General

Furnish, install, and fully integrate new local area network (LAN) equipment as called for in the Plans.

B. Requirements Definition Document

Prior to commencing work, the Contractor shall develop a Requirements Definition Document (RDD) that will form the basis for the overall network architecture and design. It is expected that the Contractor will solicit input from NCDOT and the City of Winston-Salem stakeholders in developing the following components of the RDD:

- Complete description of the proposed implementation of the access, distribution and core layers for the network as described in the Plans and these Project Special Provisions
- Development of an IP Design Scheme with ranges assigned to each node to be integrated by the Contractor using input from NCDOT (address ranges, geographic distribution, standards for addresses within each cabinet)
- Proposed IP subnet definition and addressing including any and all masks
- Proposed IP multicast configuration including multicast routing (i.e., PIM sparse or dense) and Rendezvous Point (RP) designation as necessary
- Proposed recommendations for failover and redundancy including network device power, supervisor cards, and network ports
- Proposed configuration and guidelines for L3 routing (OSPF, VRRP, EIGRP, RIP, etc.);
- Proposed configuration and guidelines for Virtual LAN assignments including management VLANs, device VLANs and routing VLANs; and
- Proposed configuration and guidelines for L2 broadcast storm prevention, loop prevention and fault tolerance mechanisms. (Spanning Tree diagram with designated, blocking and forwarding ports indicated. Root bridge and backup root bridge must also be specified.) Incorporation of Multiple Spanning Tree Protocol.
- Proposed configuration and guidelines to mitigate common security threats such as denial of service, man in the middle, MAC/IP spoofing and brute force dictionary attacks.
- Proposed configuration and guidelines for 802.1p Class of Service (COS) queue assignments
- Proposed configuration and guidelines for specific port assignments on each of the L2 and L3 devices

The Engineer will provide the Contractor with an IP address range or ranges from which the Contractor will develop the IP address scheme. The RDD shall be prepared by a qualified networking professional (minimum CCNA or a manufacturer-approved equivalent based on the

approved hardware vendor) and will be approved by the Engineer. The Qualified network professional will be present during the installation and testing of the local area network as well as during system testing.

17.2. MATERIALS

A. General

Furnish equipment for the LAN that complies with IEEE standard 802. Furnish Ethernet LAN switches that are fully compatible and interoperable with the network monitoring software, the Ethernet, and the existing firewall and switch at the TRTMC, NCDOT Division 9 Office, and City of Winston-Salem.

Furnish Ethernet Switches that comply with the following electrical safety requirements: UL60950 or CSA C22.2 No. 60950 (safety requirements for IT equipment) and FCC Part15 Class A for EMI emissions.

B. Network Performance Management and Remote Monitoring Software

Furnish network performance management and remote monitoring (RMON) software. Furnish the license(s) and additional copies of the software to allow it to be installed on all workstations (up to 10) designated by the Engineer.

Furnish software capable of monitoring all nodes and utilized ports on the enterprise. Furnish software capable of 50% expansion in the number of nodes and ports managed over the number of nodes and ports present and utilized at the final acceptance of the project as documented in the RDD.

The software shall use a GUI to configure, manage, and monitor the local network. At a minimum, the software shall provide the following functions and features:

- SNMP based
- Full management of network firewall
- Support SSH
- Utilize a GUI Web/browser style interface
- Provide a schematic display of the entire network enterprise that may be drilled down to the port level or panned out to the System level
- Provide Inventory tracking
- Provide bandwidth monitoring
- Provide SMTP support
- Provide auto alerting
- Monitor QOS
- Support management VOIP
- Support NETFLOW

- Support Wireless network management
- Receive SYSlog messages
- Generate usage/error reports
- Be capable of "pushing" upgrades to network gear via TFTP
- Detect switch failures
- Detect router failures
- Detect cable failures
- Provide network performance information
- Support the monitoring of cabinet and equipment temperature alarms via use of SNMP traps.
- Provide switch configuration backup capabilities via TFTP
- Provide configuration change tracking capabilities

C. Field Ethernet Switch

Furnish Field Ethernet switches fabricated for use in field equipment cabinets that meet or exceed NEMA TS-2 requirements for temperature, shock, humidity, and vibration.

Furnish Field Ethernet Switches that are din rail mounted and come equipment with hardware to permit mounting in an EIA 19" equipment rack.

Furnish field Ethernet Switches with internal Power Supply. Furnish field Ethernet switches meeting the following power supply requirements:

- 85 to 264 Vac (50/60Hz)/ 88 to 300Vdc.
- Power supply shall have two stage isolation accomplished via two transformers: first steps down from primary AC/DC to 48VDC; the second steps down from 48VDC to 3.3VDC.
- A power cord of not less than 5 feet in length shall be supplied

Furnish Field Ethernet Switches that weigh no more than 15 lbs and are no more than 250 cubic inches in volume.

Furnish ruggedized field Ethernet switches with the following minimum characteristics and features:

- Eight (8) 10BASE-T/100BASE-TX ports:
- Minimum of two (2) 1000 BaseX Optical uplink ports that utilize small form-factor pluggable (SFP) connectors.
- Furnish SFP modules rated to service the Field Ethernet to Field Ethernet optical uplinks and Field Ethernet to 10 Gig-E Hub Uplink rated for optical attenuation required to service the link. Use SFP modules that are LX or ZX and are matched and compatible with the SFP module it is mated with. Furnish attenuators if required to service link without saturation receiving optics.
- Furnish SFP modules rated for use with the optical cable furnished under this project.

- Furnish SFP modules with SC connector or other connector approved by the Engineer.
- SFP modules shall be considered incidental to the field Ethernet switch.
- Management console port

Furnish Field Ethernet switches with the following features:

- 10/100BaseTX ports:
  - RJ45 connectors
  - Cable type: Category 5, unshielded twisted pair (CAT 5 UTP)
  - Segment Length: 100m
  - Auto-negotiation support (10/100Mbps)
  - Auto MDIX crossover capability
  - Full Duplex operation (IEEE 802.3x)
  - TVS (transient voltage suppression) between Line +/-, Line +/ground, and Line -ground to protect the circuitry
- Networking Requirements
  - The switch shall support automatic address learning of up to 8192 MAC addresses.
  - The switch shall support the following advanced layer 2 functions:
    - IEEE 802.1Q VLAN, with support for up to 4096 VLANs
    - IEEE 802.1p priority queuing
    - IEEE 802.1w rapid spanning tree
    - IEEE 802.1s multiple spanning tree
    - IEEE802.1AD link aggregation
    - IEEE 802.3x flow control
    - IGMPv2 with 256 IGMP groups
    - Port Rate Limiting
    - Configuration via test file which can be modified through standard text editor
    - Forwarding/filtering rate shall be 14,880 packets per second (PPS) for 10Mps,148,800 for 100Mps, 1,488,000 for 1000Mps
    - DHCP Option 82
- Network Management Functionality Requirements
  - SNMPv2, SNMPv3
  - RMON
  - GVRP
  - Port Mirroring
  - 802.1x port security
  - Radius Server
  - TACACS+ Server
  - SSL – Secure Socket Layer

- SSH – Secure Shell
- TFTP,
- Network Time Protocol (NTP),
- Simple Network Time Protocol (SNTP)
- Management via web or Telnet

D. Ethernet Routing Switch

Ethernet Routing Switches will be placed in designated locations as shown on the Plans and shall meet the following requirements:

- Twelve (12) SFP Gigabit Ethernet ports and minimum of eight (8) 10/100/1000 Base-TX copper Ethernet ports
- Dynamic Host Configuration Protocol (DHCP)
- Automatic QoS (AutoQoS)
- Autonegotiation on all ports for auto selection of speed and duplexing modes.
- Link Aggregation Control Protocol (LACP)
- Automatic media-dependent interface crossover (MDIX)
- Switching Fabric of 128 Gbps
- 128 MB DRAM or greater
- 64 MB FLASH or greater
- 1000 VLANs
- 4000 VLAN IDs
- 1000 Switched Virtual Interfaces (SVIs)
- 9216 Byte Jumbo Frames or greater
- 45 Mpps Forwarding Rate or greater
- Support 1000 IGMP groups and multicast routes
- Support automatic address learning of up to 12,000 MAC addresses
- Supply a switch with the following minimum connectors:
    - Combination of up to 12 1000BASE-SX, -LX/LH, -ZX SFP-based ports: SC fiber connectors (single-mode) as needed to meet distance requirements at each Aggregation Switch and be compatible with matched Field and Core Switches provided under this project. Furnish attenuators if required to service link without saturating receiving optics.

- Fiber jumper cables with appropriate connectors to connect with switch and adjacent drop cable connectors and/or other switches.
- Ethernet management port: RJ-45 connectors, 2-pair Cat-5 UTP cabling
- Management console port: RJ-45-to-DB9 cable for PC connections
- Minimum of 8 10/100/1000 Base-TX copper RJ-45 connectors

- Security:
  - DHCP Snooping
  - Dynamic ARP Inspection (DAI)
  - Secure Shell (SSH) Protocol, EAP, and Simple Network Management Protocol Version 3 (SNMPv3), Network Time Protocol Version 3 (NTPv3)
  - Port Mirroring
  - TACACS+ and RADIUS authentication
  - MAC Address Notification
  - Port Security
  - Bridge protocol data unit (BPDU) protection and filtering
  - Root Guard
  - IGMP snooping
  - Dynamic VLAN assignment
- Standards: Supply a L3 Ethernet switch that meets or exceeds the following standards:
  - IEEE 802.1s Multiple Spanning Tree Protocol
  - IEEE 802.1w Rapid Reconfiguration Spanning Tree Protocol
  - IEEE 802.1x
  - IEEE 802.3ad
  - IEEE 802.3af
  - IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports
  - IEEE 802.1D Spanning Tree Protocol
  - IEEE 802.1p CoS Prioritization
  - IEEE 802.1Q VLAN
  - IEEE 802.3 10BASE-T specification

- IEEE 802.3u 100BASE-TX specification
- IEEE 802.3ab 1000BASE-T specification
- IEEE 802.3z 1000BASE-X specification
- RFC 2338 Virtual Router Redundancy Protocol (VRRP)
- OSPFv2 and v3: RFC 2328 for IPv4 and RFC 5340 for IPv6
- L3 features required for compatibility with the L3 Core Switches

- Supply a L3 Switch with the following Indications:
  - Per-port status LEDs: link integrity, disabled, activity, speed, and full-duplex indications
  - System-status LEDs: system, power supplies, fans, and bandwidth utilization indications
- Environmental Requirements:
  - Furnish L3 Field Aggregation Switches fabricated for use in field equipment cabinets that meet or exceed NEMA TS-2 requirements for temperature, shock, humidity, and vibration.
- Acoustic Noise: Compliant with ISO 7779 or ISO 7296
- Mean Time Between Failures of greater than 80,000 hours
- Power Supply
  - Rated to handle input power of 115 VAC/60Hz (± 10%)
  - Power supply shall have two stage isolation accomplished via two transformers step down from primary AC/DC to VDC
- Physical Requirements
  - Shelf-mounted with optional DIN-rail/rack mounting
  - 500 cubic inch maximum
- Safety Requirements
  - UL60950 or CSA C22.2 No. 60950
  - FCC Part 15 Class A for EMI emissions

E. Ethernet Core Switch

Ethernet Core Switches will be placed as shown in the Plans, and shall meet the following requirements:

- L3 core modular, high-availability, switch equipped with redundant fans, power supplies, and support for redundant supervisor/route processor engines, or approved equivalent functionality.
- A minimum of four (4) slots for switch/routing processor modules, but at least one spare slot shall remain after configuring required ports/interfaces herein.
- Copper Ethernet modules shall support a minimum of 24 ports of 10/100/1000 Base-T.
- SFP fiber modules shall support a minimum of 24 SFP ports.
- Supply a switch with the following minimum connectors:
    - A minimum combination of 12 1000BASE-SX, -LX/LH, -ZX SFP-based ports: SC fiber connectors (single-mode) as needed to meet distance requirements at each Core Switch and to be compatible with matched Field and Aggregation Switches to support the distances shown in the Plans for switches connected to the Core switches. Furnish attenuators if required to service link without saturating receiving optics.
    - Equip with four (4) SFP ports for short-range connection with nearby switches using multi-mode (MMFO)
    - Fiber jumper cables with appropriate connectors to connect with switch and adjacent drop cable connectors and/or other switches.
    - Ethernet management port: RJ-45 connectors, 2-pair Cat-5 UTP cabling
    - Management console port: RJ-45-to-DB9 cable for PC connections
    - Minimum of 48 10/100/1000 Base-TX copper RJ-45 connectors
- Dynamic Host Configuration Protocol (DHCP)
- Automatic QoS (AutoQoS)
- Autonegotiation on all ports for auto selection of speed and duplexing modes.
- Link Aggregation Control Protocol (LACP)
- Automatic media-dependent interface crossover (MDIX)
- Switching Capacity per line card 300 Gbps
- 256 MB DRAM or greater
- 128 MB FLASH or greater
- 1000 VLANs
- 4000 VLAN IDs
- 1000 Switched Virtual Interfaces (SVIs)

- 9216 Byte Jumbo Frames or greater
- 100 Mpps Forwarding Rate or greater
- Support 1000 IGMP groups and multicast routes
- Support automatic address learning of up to 12,000 MAC addresses
- Security:
    - DHCP Snooping
    - Dynamic ARP Inspection (DAI)
    - Secure Shell (SSH) Protocol, EAP, and Simple Network Management Protocol Version 3 (SNMPv3), Network Time Protocol Version 3 (NTPv3)
    - Port Mirroring
    - TACACS+ and RADIUS authentication
    - MAC Address Notification
    - Port Security
    - Bridge protocol data unit (BPDU) protection and filtering
    - Root Guard
    - IGMP snooping
    - Dynamic VLAN assignment
- Standards: Supply a L3 Ethernet switch that meets or exceeds the following standards:
    - IEEE 802.1s Multiple Spanning Tree Protocol (64 regions)
    - IEEE 802.1w Rapid Reconfiguration Spanning Tree Protocol
    - IEEE 802.1x
    - IEEE 802.3ad
    - IEEE 802.3af
    - IEEE 802.3x full duplex on 10BASE-T, 100BASE-TX, and 1000BASE-T ports
    - IEEE 802.1D Spanning Tree Protocol
    - IEEE 802.1p CoS Prioritization
    - IEEE 802.1Q VLAN
    - IEEE 802.3 10BASE-T specification
    - IEEE 802.3u 100BASE-TX specification

- IEEE 802.3ab 1000BASE-T specification
- IEEE 802.3z 1000BASE-X specification
- An IP gateway redundancy protocol such as virtual router redundancy protocol (VRRP – RFC 2338), hot-standby router protocol (HSRP - proprietary) or gateway load balancing protocol (GLBP - proprietary), or an approved equal will be used to provide a redundant IP gateway in the event of a primary gateway failure.
- OSPFv2 and v3: RFC 2328 for IPv4 and RFC 5340 for IPv6

- Supply a L3 Switch with the following Indications:
  - Per-port status LEDs: link integrity, disabled, activity, speed, and full-duplex indications
  - System-status LEDs: system, power supplies, fans, and bandwidth utilization indications
- Environmental Requirements:
  - Operating temperature: 0°C to 40°C minimum range
  - Relative humidity operating: 5 to 90% (non-condensing)
- Mean Time Between Failures of greater than 80,000 hours
- Power Supply
  - Rated to handle input power of 115 VAC/60Hz (± 10%), unless otherwise approved by the Engineer
  - Hot-swappable redundant modules
- Physical Requirements
  - EIA standard rack mounting in an IT equipment cabinet
  - No larger than 10 RU
- Safety Requirements
  - FCC Part 15 Class A for EMI emissions

F. Category 6 Cable and Wall Information Outlets

Furnish Category 6 network cable, EIA-232, monitor cabling, and all other cabling in the lengths required to interconnect devices as called for in the Plans, Project Special Provisions, and manufacturers requirements. Furnish quality and grade of cable capable of being operable at up to twice the distance installed on this project. Furnish cabling meeting all manufacturers' requirements and all applicable standards for performance and safety, including TIA/EIA-568A requirements.

Furnish wall information outlets as required, with RJ-45, RJ-11, BNC, or other connectors as required to terminate cabling in walls for connection to devices and components.

G. LAN Patch Panel

Furnish LAN Patch Panels in the locations shown in the Plans. Patch panels shall be rack-mounted.

Furnish patch panels that meet or exceed Category 6 transmission requirements of TIA/EIA-568A supporting bandwidths up to 300 MHz. Furnish patch panels that are UL-listed. Furnish patch panels that provide for rear punch down termination of horizontal cables from the office workspaces, provide at least 48 ports and occupy no more than 2 RUs mounting height EIA standard 19" equipment rack. All ports shall provide 8-position modular jacks for jumper cables and they shall be accessible from the front of the patch panel. Jumper cables shall be neatly arranged using cable management guides or an approved equivalent.

17.3. CONSTRUCTION METHODS

A. General

Furnish media access control (MAC) addresses for all equipment utilized as part of this project. Affix MAC Address label to each device utilized. Furnish IP addresses for all equipment utilized as part of this project. Affix final IP address each device utilized. Use labels that do not smear or fade.

In field equipment cabinets, fully integrate new Ethernet switches with the fiber optic interconnect centers. Integrate all field equipment as call for.

Fully integrate LAN to accomplish local device failover and fault tolerance.

Fully integrate LAN equipment to provide virus protection, user authentication, and security functions to prevent unauthorized users and data from entering the LAN.

B. Ethernet LAN Switches

Install and integrate all Ethernet switches at field locations as depicted in the diagrams and tables and called for in these Project Special Provisions. Integrate with computer hardware, and field devices as called for.

Provide inline surge protection for all Ethernet connections in field cabinets.

Configure and test all Ethernet equipment prior to installation.

17.4. MEASUREMENT AND PAYMENT

(___) switch will be measured and paid for as the actual number of Ethernet switches furnished, installed, and accepted. All SFP modules, optics, cabling, attenuators, configuration, and testing or other labor or materials required to install and integrate the field Ethernet Switch will be considered incidental and not be paid for separately.

LAN integration will be paid for and measured as lump sum. LAN integration includes configuration and integration of all LAN hardware, firmware, and software to complete the LAN architecture, and submittal of the RDD. Integration of the existing firewall and integration of Internet based software applications with existing Internet connection infrastructure shall be incidental and not paid for separately. All cabling, hardware, accessories, labor, and materials required to make the unit function as part of this project shall be considered incidental and not paid for separately. Furnishing, installing, and configuring the LAN Network Performance Management

and Remote Monitoring Software shall be included as part of the LAN integration and not paid for separately. Partial payments for this item will be made on the following schedule: 20% upon completion and acceptance of the RDD; 20% upon installation, integration and acceptance of LAN equipment, 20% upon installation, integration and acceptance of LAN equipment at Routing Switch locations, 20% upon deployment and acceptance of the Network Performance Management and Monitoring Software, and 20% upon installation, integration and acceptance of the entire project furnishing of and acceptance of network as-built documentation.

Payment for all cabling, jumpers, adapters, sockets, LAN patch panels, and other hardware shall be considered incidental and no separate payment will be made.

Payment will be made under:

Field Ethernet Switch ..... Each
Ethernet Routing Switch ..... Each
Ethernet Core Switch ..... Each
LAN Integration ..... Lump Sum

18. ETHERNET CABLE (OUTDOOR RATED)

18.1. DESCRIPTION

Furnish and install Ethernet cable to serve as interconnect between Ethernet switches and/or field devices routed in outdoor conduit and/or lashed to messenger cable and existing cables.

18.2. MATERIALS

Furnish CAT5E Ethernet cable that is suitable for outdoor installation and meets or exceeds the following standards:

- 4-pair shielded twisted pair cable
- 24AWG (minimum) solid bare copper conductor
- Meets or exceeds CAT5E specifications
- High-density polyethylene insulation, PVC jacket
- Compliant with EIA/TIA standards
- UL/CSA listed
- UV Stabilized PE Jacket
- Gel Filled
- Meets TIA/EIA 568B.2 Networking Standard
- Supports 10/100/1000/10,000Mbps
- Mean Power Sum for Equal Level Fare End Crosstalk (ELFEXT): 45dB/kft (minimum) at 772kHz
- Worst Pair Power Sum for ELFEXT· 40dB/kft (minimum) at 772kHz
- Mean Power Sum for Near-end Crosstalk (NEXT): 42dB/kft (minimum) at 772 kHz
- Operating Temperature: Rated from -10 to +60 Celsius
- Average mutual capacitance: 90nf/mile (maximum)

Have the manufacturer factory test the communications cable on reels for each pair's mutual capacitance, crosstalk loss, insulation resistance, and conductor resistance. Furnish the Engineer with a certified report for each reel showing compliance with these Project Special Provisions, the factory test results, and the manufactured date of the cable. The contractor shall not use communications cable manufactured more than one year before the date of installation.

Cables where both ends will terminate in an RJ-45 connector, both ends should be installed with punchdown female jacks at both ends of the factory-manufactured cable, to be connected at both ends with short 3-6' patch cables.

Cable length with end patch connectors shall not exceed 295 feet.

18.3. CONSTRUCTION METHODS

A. General

Install Ethernet cable on new or existing messenger cable and in conduits at locations shown in the Plans. Allow a minimum of 10 feet (3 meters) of cable slack.

Ethernet cables shall not be spliced.

All cables shall be labeled with water proof, smear resistant labels that denote the equipment cabinets or housing they are run from and the device and identifier for that device they are connected to (e,g. CCTV Cabinet 31; CODEC at CCTV Cabinet 31).

B. Aerial Installation

Double lash the communications cable to the messenger cable where installed aerially.

Wrap the communications cable to the messenger cable using aluminum ribbon wraps where the wire supports other cables.

C. Underground Installation

Install underground communications cable in conduit described in these Special Provisions.

The contractor shall not exceed 80 percent of the manufacturer's maximum pulling tension when installing underground communications cable. Use a clutch device (dynamometer) so as not to exceed the allowable pulling tension if the cable is pulled by mechanical means. Do not use a motorized vehicle to generate cable-pulling forces.

Keep tension on the cable reel and the pulling line at the start of each pull. Do not release the tension in the cable if the pulling operation is halted. Restart the pulling operation by gradually increasing the tension until the cable is in motion. Do not pull the cable through intermediate junction boxes, pull boxes, handholes, or openings in conduit unless otherwise approved by the Engineer.

18.4. MEASUREMENT AND PAYMENT

Ethernet cable (outdoor rated) will be measured and paid as linear feet of outdoor rated Ethernet cable furnished, installed, and accepted. Sag and vertical segments will not be paid for as these distances are considered incidental to the installation of the cable.

Ethernet cabling installed within equipment cabinets, within rooms, and within buildings are incidental and will not be paid for under this item.

No measurement will be made for terminating and testing of the cable, cable identification markers, and grounding, as these will be considered incidental to the installation of the Ethernet cable.

Payment will be made under:

Ethernet Cable (Outdoor Rated) ..... Linear Feet

19. TRUCK ROLLOVER SYSTEM

19.1. DESCRIPTION

Furnish, install, and fully integrate a complete automated truck rollover warning system at the southwest loop (SB US 52 to EB I-40) on the I-40/US 52 interchange as shown on the Plans.

The system shall be a commercial off-the-shelf (COTS) package that has been deployed and in continuous operation at a minimum of three (3) locations in North America within the past three (3) years.

The following are functional specifications for the system and thus the Contractor shall be responsible for providing the necessary types and quantity of equipment and installing them in the necessary locations along the roadway to meet the required functionality.

19.2. Functional Requirements

A. General

The system shall be a closed system where all processing is accomplished at the local controller.

A remote connection using the wireless radio system called for in these Project Special provisions shall be included for monitoring and archived data collection features only. Provide licenses for up to 30 seats of any required central software. Install software at the TRTMC.

The detection and notification shall be located such that a driver has time to react to any notification and make necessary adjustments before entering the curve.

B. Vehicle Detection

All vehicle information shall be gathered upstream of the specified curve.

Vehicle detectors shall provide the system controller with relevant data (vehicle classification, weight, height, speed, and deceleration) for each vehicle in the lane. At a minimum, vehicle classification and speed shall be detected.

C. System Controller

The system controller shall use a reliable algorithm to process each vehicle's data in relation to the curve's radius and superelevation and determine if a rollover is possible. Upon determining a rollover is possible, the controller shall activate the driver notification.

The system controller shall regularly test each of the components and system as a whole periodically. In the event a failure is observed, the system controller shall immediately send an alarm to the TRTMC.

The system controller shall have a serial port for connection to a user laptop for configuration of the system.

The system controller shall be native IP and have an ethernet port for integration with the wireless radio system and ethernet network.

The system controller shall be housed in an environmentally-hardened and locked enclosure.

The system controller shall have a wired electrical service connection and a battery back-up capable of providing 24 hours of continuous power in the event of an outage.

D. Driver Notification

The notification shall consist of a static sign and flashing beacon. The static sign shall be an NCDOT typical yellow truck rollover warning sign. The flashing beacon shall be two flashing yellow lights posted on the static sign. The beacons shall only flash when a potential rollover occurrence is detected.

19.3. MATERIALS

To the fullest extent possible, all material, equipment, and hardware furnished under this section shall be pre-approved on the Department's QPL.

Vehicle detection equipment can be intrusive (such as inductive loops imbedded in the roadway) or non-intrusive (such as microwave detectors on the side of the roadway).

All signage and flashing beacons shall conform to the MUTCD, the NCDOT Standard Specifications, and these Project Special Provisions. The Engineer shall approve all signs prior to fabrication.

19.4. CONSTRUCTION METHODS

All construction methods shall conform to AASHTO standards for roadside devices, the NCDOT Standard Specifications, and these Project Special Provisions.

19.5. MEASUREMENT AND PAYMENT

Truck rollover system will be paid for as the lump sum price. Such lump sum price will be full payment for all material covered under this section including, but not limited to, all vehicle detection, controllers, software, signage, flashing beacons, enclosures, cabling, electrical service and power supplies, risers, conduit, connectors, pole attachment assemblies, grounding equipment, surge protectors, software, communications equipment, testing, documentation, and any integration necessary to provide the system as described in these Project Special Provisions.

Payment will be made under:

Truck Rollover System ..... Lump Sum

20. DYNAMIC MESSAGE SIGN (DMS)

20.1. DESCRIPTION

To ensure compatibility with the existing DMS control software deployed in the State, furnish NTCIP compliant DMS that are compatible with Daktronics Vanguard Professional (Version 4) software (also referred to hereinafter as the "Control Software"). Full matrix (27 pixels x 90 pixels) DMSs must be preapproved on the current NCDOT ITS & Signals Qualified Products List (QPL) by the date of installation. The QPL is available on the Department's website. The QPL website is: http://www.ncdot.org/doh/preconstruct/traffic/ITSS/SMS/qpl/

Furnish and install DMSs compliant with UL standards 48, 50, 879, and 1433.

Add and configure the new DMSs in the system using the Control Software and computer system. Furnish, install, test, integrate and make fully operational the new DMSs at locations shown in the Plans.

Furnish operating DMS systems consisting of, but not limited to, the following:

- Full Matrix, 27 pixels high and 90 pixels wide Walk-In LED DMS
- Full Matrix, 27 pixels high and 60 pixels wide Front Access LED DMS
- Pedestal type DMS support structure and mounting hardware
- Overhead type DMS support structure and mounting hardware
- DMS controllers, Uninterruptible Power Supplies (UPS), cabinets and accessories with interconnect and power cabling and conduit
- Electrical service and related equipment
- All other equipment and incidentals required for furnishing, installing, and testing the DMS system and system components

Use only UL listed and approved electronic and electrical components in the DMS system.

The following table is a summary of the DMS enclosure and structure types as shown in the Plans.

DMS No.	Enclosure Type	Structure Type
1	Walk-In	Full-Span
2	Walk-In	Pedestal
3	Walk-In	Pedestal
4	Walk-In	Existing
5	Front Access	Pedestal
6	Front Access	Pedestal
7	Front Access	Pedestal
8	Front Access	Pedestal
9	Front Access	Pedestal
10	Walk-In	Full-Span
11	Front Access	Pedestal

20.2. MATERIALS

A. Environmental Requirements

Construct the DMS and DMS controller cabinet so the equipment within is protected against moisture, dust, corrosion, and vandalism. Design the DMS system to comply with the requirements of Section 2.1 (Environmental and Operating Standards) of NEMA TS 4-2005.

B. Full Matrix LED Dynamic Message Sign (DMS)

Construct the DMS to display at least three lines of text that, when installed, are clearly visible and legible to a person with 20/20 corrected vision from a distance of 900 feet in advance of the DMS at an eye height of 3.5 feet along the axis.

For DMS that are 27 pixels high and 60 pixels wide, the entire LED matrix shall be 27 pixels high and 60 pixels wide. When displaying three lines, each line must display at least eight equally spaced and equally sized alphanumeric individual characters. For DMS that are 27 pixels high and 90 pixels wide, the entire LED matrix shall be 27 pixels high and 90 pixels wide. When displaying three lines, each line must display at least 15 equally spaced and equally sized alphanumeric individual characters. Each character must be at least 18 inches in height and composed from a luminous dot matrix.

1. DMS Enclosure

Comply with the requirements of Section 3 (Sign Mechanical Construction) of NEMA TS 4-2005. Construct the 27x90 DMS with a metal walk-in enclosure excluding the face. Provide an aluminum walking platform inside the enclosure that is at least 28 inches wide. Ensure the width of the walking platform is free of obstructions to a height of 7 feet. Construct the enclosure of welded aluminum type 6061-T6, 5052-H38, 5052-H34, or of an Engineer approved

alternate at least 1/8-inch thick. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW).

Provide one key lockable, hinged, gasket-sealed inspection door for service and maintenance along each side of the enclosure. Install one appropriately sized fire extinguisher within 12 inches of each maintenance door. Equip the DMS enclosure with internal fluorescent lighting controlled by timers installed close to each inspection door. Make certain no light emitted from the fluorescent tubes or any other light source inside the enclosure not comprising the display is leaked to the outside of the enclosure. Equip the door with a door-hold-open device. Install GFCI duplex utility receptacles every 6 feet along the width of the DMS in convenient locations for powered service tools.

For 27x60 DMS, provide one front access door for each 10 to 15 pixel wide section of the sign enclosure. Vertically hinge the doors and design to swing out from the face to provide access to the enclosure interior. Extend each door the full height of the display matrix.

Provide a retaining latch mechanism for each door to hold the door open at a 90-degree angle.

Each door will form the face panel for a section of the sign. Mount the LED modules to the door such that they can be removed from the door when in the open position. Other sign components can be located inside the sign enclosure and be accessible through the door opening.

Provide for each door a minimum of two (2) screw-type captive latches to lock them in the closed position and pull the door tight and compress a gasket located around the perimeter of each door. Install the gasket around the doors to prevent water from entering the cabinet.

Provide all exterior and interior DMS enclosure surfaces with natural, mill-finish aluminum. Remove all grind marks and discoloration from the surfaces.

Provide corrosion resistant nuts, bolts, washers, and other mounting and bonding parts and components used on the exterior of the DMS enclosure and ensure they are sealed against water intrusion.

Furnish the sign face, excluding the front, panel with a flat black, UV treated, colorfast material. Prepare all surfaces for application according to the sheeting manufacturer's recommendations prior to applying the sheeting. Construct UV-treated, colorfast border with a minimum width of 18 inches.

Provide three photoelectric sensors installed inside the DMS enclosure monitoring front, back and bottom of the sign or north sky.

Do not place a manufacturer name, logo, or other information on the front face of the DMS or shield visible to the motorist.

Provide power supply monitoring circuitry to detect power failure in the DMS and to automatically report this fault to the Control Software. This requirement is in addition to reporting power failure at the controller cabinet.

Do not paint the stainless steel bolts on the Z-bar assemblies used for mounting the enclosure.

2. DMS Interior Environment Control for Walk-In Enclosures

Design the local field controller to monitor and control the interior DMS environment. Design environmental control to maintain the internal DMS temperature within +/- 10° F of the outdoor ambient temperature. Provide the DMS environmental control system with four primary subsystems as follows:

Internal Temperature Sensors – Provide the DMS with two internally mounted temperature sensors which are equipped with external thermocouples and which the field controller continuously monitors. Design the field controller to use this temperature information to determine when to activate and deactivate the environmental control systems described herein. Locate sensors on opposite ends of the upper 1/3 of the LED display matrix with their external thermocouples attached to and making contact with an LED pixel circuit board. Design the thermocouple and LED board to be easily detachable, in the event that one of the units requires removal and replacement. Provide sensors capable of measuring temperatures from -40° F to +185° F. Design the field controller to automatically shut down the LED display whenever one or both sensors indicates that LED board temperature has exceeded +140° F, and to automatically restart the LED display whenever the temperature falls below +130° F. Design both shutdown and re-start temperature thresholds to be user-programmable. Design the field controller to report sensor temperatures and DMS shutdown/re-start events to the DMS Control Software.

Housing Cooling System – Provide the DMS housing with a cooling system that circulates outside air into the DMS housing whenever the LED board temperature exceeds a user-programmable threshold. Provide this system with enough ventilation fans to exchange the internal DMS housing air volume at a minimum rate of 4 times per minute. Provide steel ball-bearing type fans. Mount fans in a line across the upper rear wall of the DMS housing to direct air out of the cabinet. Provide one filtered air intake port for each exhaust fan. Locate intake ports in a line across the lower rear wall of the DMS housing. Provide intake ports with a removable filter that will remove airborne particles measuring 500 microns in diameter and larger. Provide a filter that is of a size and style that is commercially readily available. Program the field controller to activate the DMS housing cooling system whenever the LED board temperature exceeds +90° F and to turn the cooling system off whenever LED board temperature falls below +85° F. On the DMS housing rear exterior wall, cover all air intake and exhaust ports on their top, front, and sides by an aluminum shroud fabricated from 0.090-inch aluminum sheeting. Taper the shrouds at the top. Securely fasten shrouds to the DMS housing, and provide gaskets at the interface to prevent water from entering the DMS. Design all air filters and fans to be removable from inside the DMS housing. Provide the DMS housing cooling system with an adjustable timer that will turn fans off after the set time has expired. Provide a timer that is adjustable to at least 4 hours, and locate it just inside the DMS housing door, within easy reach of a maintenance technician standing outside the DMS doorway.

LED Display Cooling System – Provide the DMS with an LED display cooling system which directs air across the LED display modules whenever LED board temperature exceeds a user-programmable threshold. Direct fan-forced air vertically across the backside of the entire LED display matrix using multiple ball-bearing fans. Program the field controller to activate the LED cooling fan system whenever LED board temperature exceeds +90° F and to deactivate the system whenever LED board temperature falls to +85° F. Locate cooling fans so as not to hinder removal of LED display modules and driver boards.

Front Face Panel Defog/Defrost System – Provide the DMS with a defog/defrost system which circulates warm, fan-forced air across the inside of the polycarbonate front face whenever LED board temperature falls below a user-programmable threshold. Provide multiple steel ball-bearing fans that provide uniform airflow across the face panel. Program the field controller to activate the defog/defrost system whenever LED board temperature falls below +40° F and to deactivate the defog/defrost system whenever LED board temperature exceeds +106° F. Mount a 100-watt pencil-style heating element in front of each defog/defrost fan to warm the air directed across the DMS face. Design heating elements to be on only when the defog/defrost fans are on.

Install additional fans and/or heaters as needed to maintain the temperature inside the DMS enclosure within the operating temperature range of the equipment within the DMS enclosure as recommended by the equipment manufacturer(s).

3. DMS Interior Environment Control for Front Access Enclosures

Install a minimum of one (1) temperature sensor that is mounted near the top of the DMS interior. The sensor(s) will measure the temperature of the air in the enclosure over a minimum range of -40°F to +176°F. Ensure the DMS controller will continuously monitor the internal temperature sensor output and report to the DMS control software upon request.

Design the DMS with systems for enclosure ventilation, face panel fog and frost prevention, and safe over-temperature shutdown.

Design the DMS ventilation system to be thermostatically controlled and to keep the internal DMS air temperature lower than +140°F, when the outdoor ambient temperature is +115°F or less.

The ventilation system will consist of two or more air intake ports located near the bottom of the DMS rear wall. Cover each intake port with a filter that removes airborne particles measuring 500 microns in diameter and larger. Mount one or more ball bearing-type fans at each intake port. These fans will positively pressure the DMS enclosure.

Design the fans and air filters to be removable and replaceable from inside the DMS housing. To ease serviceability, mount the fans no more than four (4) feet from the floor of the DMS enclosure.

Provide each ventilation fan with a sensor to monitor its rotational speed, measured in revolutions per minute and report this speed to the sign controller upon request.

The ventilation system will move air across the rear of the LED modules in a manner such that heat is dissipated from the LED's. Design the airflow system to move air from the bottom of the enclosure towards the top to work with natural convection to move heat away from the modules.

Install each exhaust port near the top of the rear DMS wall. Provide one exhaust port for each air intake port. Screen all exhaust port openings to prevent the entrance of insects and small animals.

Cover each air intake and exhaust port with an aluminum hood attached to the rear wall of the DMS. Thoroughly seal all intakes and exhaust hoods to prevent water from entering the DMS.

Provide a thermostat near the top of the DMS interior to control the activation of the ventilation system.

The DMS shall automatically shut down the LED modules to prevent damaging the LEDs if the measured internal enclosure air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and shall have a default factory setting of 140°F

4. Front Panel

Protect the DMS face with contiguous, weather-tight, removable panels. Manufacture these panels of sheets of polycarbonate, methacrylate, GE Lexan Type SG300 or equivalent that are ultraviolet protected, have an antireflection coating, and are a minimum of 1/8- inch thick. For substitutes, submit one 12" x 12" sample of the proposed material together with a description of the material attributes to the Engineer for review and approval. Install a .09" aluminum mask on the front of the panel (facing the motorists) that contains a circular opening for each LED pixel. Prime and coat the front side of the aluminum mask, which faces the viewing motorists, with automotive-grade flat black acrylic enamel paint or an approved equivalent. Guarantee all painted surfaces provide a minimum outdoor service life of 20 years.

Design the panels so they will not warp nor reduce the legibility of the characters. Differential expansion of the DMS housing and the front panel must not cause damage to any DMS component or allow openings for moisture or dust. Glare from sunlight, roadway lighting, commercial lighting, or vehicle headlights must not reduce the legibility or visibility of the DMS. Install the panels so that a maintenance person can easily remove or open them for cleaning.

For front access DMS enclosures, securely attach a single 1/8-inch thick polycarbonate sheet to cover all of the pixel openings to the inside of each aluminum door panel. Seal the polycarbonate to prevent water and other elements from entering the DMS. Mount the LED display modules to the inside of the DMS front face door panels. Ensure common hand tools can be used for removal and replacement.

5. Display Modules

Manufacture each display module with a standard number of pixels, not to exceed an array of 9 x 5, which can be easily removed. Assemble the modules onto the DMS assemblies contiguously to form a continuous matrix to display the required number of lines, characters, and character height.

Design display modules that are interchangeable and replaceable without using special tools. Provide plug-in type power and communication cables to connect to a display module.

Construct each display module as a rectangular array of 5 horizontal pixels by 7 to 9 vertical pixels. Provide the module with an equal vertical and horizontal pitch between pixels, and columns that are perpendicular to the rows (i.e., no slant). Design each module to display:

- All upper and lower case letters.
- All punctuation marks.
- All numerals 0 to 9.
- Special user-created characters.

Display upper-case letters and numerals over the complete height of the module. Optimize the LED grouping and mounting angle within a pixel for maximum readability.

6. Discrete LEDs

Provide discrete LEDs with a nominal viewing cone of **30 degrees** with a half-power angle of 15 degrees measured from the longitudinal axis of the LED Make certain, the viewing cone

tolerances are as specified in the LED manufacturer's product specifications and do not exceed +/- 3 degrees half-power viewing angle of 30 degrees.

Provide LEDs that are untinted, non-diffused, high output solid state lamps utilizing indium gallium aluminum phosphide (InGaAlP) technology manufactured by Toshiba or Hewlett-Packard. No substitutions will be allowed. Provide T1 ¾, 0.2 inch size LEDs that emit a true amber color at a wavelength of 590 ± 5 nm.

Provide LEDs with a MTBF (Mean Time Before Failure) of at least 100,000 hours of permanent use at an operating point of 140° F or below at a specific forward current of 20mA. Discrete LED failure is defined as the point at which the LED's luminous intensity has degraded to 50% or less of its original level.

Obtain the LEDs used in the display from a single LED manufacturer that have a single part number. Obtain them from batches sorted for luminous output, where the highest luminosity LED is not more than fifty percent more luminous than the lowest luminosity LED when the LEDs are driven at the same forward current. Do not use more than two successive and overlapping batches in the LED display. **Document the procedure to be used to comply with this requirement as part of the material submittal.**

Individually mount the LEDs on circuit boards that are at least 1/16"thick FR-4 fiberglass, flat black printed circuit board in a manner that promotes cooling. Protect all exposed metal on both sides of the LED pixel board (except the power connector) from water and humidity exposure by a thorough application of acrylic conformal coating. Design the boards so bench level repairs to individual pixels, including discrete LED replacement and conformal coating repair is possible.

Operate the LED display at a low internal DC voltage not to exceed 24 Volts.

Design the LED display operating range to be –20° F to +140° F at 95% relative humidity, non-condensing.

Supply the LED manufacturer's technical specification sheet with the material submittals.

7. LED Power Supplies

Power the LED Display by means of multiple regulated switching DC power supplies that operate from 120 volts AC input power and have an output of 48 volts DC or less. Wire the supplies in a redundant parallel configuration that uses multiple power supplies per display. Provide the supplies with current sharing capability that allows equal amounts of current to their portion of the LED display. Provide power supplies rated such that if one supply fails the remaining supplies will be able to operate their portion of the display under full load conditions (i.e. all pixels on at maximum brightness) and at a temperature of 140° F.

Provide power supplies to operate within a minimum input voltage range of +90 to +135 volts AC and within a temperature range of –22° F to 140° F. Power supply output at 140° F must not deteriorate to less than 65% of its specified output at 70° F. Provide power supplies that are overload protected by means of circuit breakers, that have an efficiency rating of at least 75%, a power factor rating of at least .95, and are UL listed. Provide all power supplies from the same manufacturer and with the same model number. Design the power driver circuitry to minimize power consumption.

Design the field controller to monitor the operational status (normal or failed) of each individual power supply and be able to display this information on the Client Computer screen.

8. LED Pixels

A pixel is defined as the smallest programmable portion of a display module that consists of a cluster of closely spaced discrete LEDs. Design each pixel to be a maximum of 2 inches in diameter.

Construct the pixels with two strings of LEDs. It is the manufacturer's responsibility to determine the number of LEDs in each string to produce the candela requirement as stated herein.

Ensure each pixel produces a luminous intensity of 40 Cd when driven with an LED drive current of 20 mA per string.

Power the LEDs in each pixel in strings. Use a redundant design so that the failure of an LED in one string does not affect the operation of any other string within the pixel. Provide the sign controller with the ability to detect the failure of any LED string and identify which LED string has failed. Submit a complete schematic of the LED power and driver circuits with the material submittals.

9. Character Display

Design display modules to be easily removable without the use of tools. Position cooling fans so they do not prevent removal of an LED pixel board or driver board.

Use continuous current to drive the LEDs at the maximum brightness level. Design the light levels to be adjustable for each DMS / controller so the Engineer may set levels to match the luminance requirements at each installation site.

Design the controller to automatically detect failed LED strings or drivers and initiate a report of the event to the Control Software. Design the controller to be able to read the internal temperature of the DMS enclosure and the ambient temperature outside the DMS enclosure and report these to the Control Software.

10. Display Capabilities

Design the DMS with at least the following message displays:

Static display

Flashing display with Dynamic flash rates

At least two alternating Static and / or Flashing sequences (multi-page messages)

11. DMS Mini Controller

Furnish and install a mini controller inside the walk-in DMSs that is interconnected with the main controller using a fiber optic cable, CAT-5 cable, or an approved alternate. The mini controller will enable a technician to perform all functions available from the main controller. Provide the mini controller with an LCD/keypad interface. Size the LCD display screen to allow preview of an entire one-page message on one screen. Provide a 4 X 4 keypad.

Alternatively, install an EIA/TIA-232E port inside the DMS enclosure to enable a maintenance technician to communicate with the DMS main controller and obtain access to and perform all functions of the main controller using a laptop computer.

C. DMS Enclosure Structure Mounting

Mount the DMS enclosure and interconnect system securely to the supporting structures of the type specified in the Plans. Design the DMS enclosure supports and structure to allow full access to the DMS enclosure inspection door. On existing structures, ensure the walkway does not interfere with full access to the DMS enclosure inspection door.

Furnish and install U-bolt connections of hanger beams to overhead assembly truss chords with a double nut at each end of the U-bolt. Bring the double nuts tight against each other by the use of two wrenches.

Submit plans for the DMS enclosure, structure, mounting description and calculations to the Engineer for approval. Have such calculations and drawings approved by a Professional Engineer registered in the state of North Carolina, and bear his signature, seal, and date of acceptance.

Provide removable lifting eyes or the equivalent on the DMS enclosure rated for its total weight to facilitate handling and mounting the DMS enclosure.

Design the DMS structure to conform to the applicable requirements of the *Standard Specifications for Structural Supports for Highway Signs, Luminaires*, and the section titled "DMS Assemblies" of these Project Special Provisions.

D. DMS / DMS Controller Interconnect

Furnish and install all necessary cabling, conduit, and terminal blocks to connect the DMS and the DMS controller. Use approved manufacturer's specifications and the Plans for cable and conduit types and sizes. Use fiber optic cable to interconnect sign and controller. Install fiber optic interconnect centers in the sign enclosure and cabinet to securely install and terminate the fiber optic cable. Submit material submittal cut sheets for the interconnect center.

Furnish and install one DMS controller with accessories per DMS in a protective cabinet. Mount the controller cabinet on the DMS support structure. Install cabinet so that the height to the middle of the cabinet is 4 feet. Ensure a minimum of 3 feet level working surface under each cabinet that provides maintenance technicians with a safe working environment.

Provide the DMS controller as a software-oriented microprocessor and with resident software stored in non-volatile memory. The Control Software, controller and communications must comply with the NTCIP Standards identified in these Project Special Provisions. Provide sufficient non-volatile memory to allow storage of at least 500 multi-page messages and a test pattern program.

Furnish the controller cabinet with, but not limited to, the following:

- Power supply and distribution assemblies
- Power line filtering hybrid surge protectors
- Radio Interference Suppressor
- Communications surge protection devices
- Industrial-Grade UPS system and local disconnect
- Microprocessor-based controller
- Display driver and control system (unless integral to the DMS)
- Industrial-grade dial-up modem and interface cable

- Industrial-grade telephone line surge and lightning protector
- Serial interface port for local laptop computer
- Local user interface
- Interior lighting and duplex receptacle
- Adjustable shelves as required for components
- Temperature control system
- All interconnect harnesses, connectors, and terminal blocks
- All necessary installation and mounting hardware

Furnish the DMS controller and associated equipment completely housed in a NEMA 3R cabinet made from 5052-H32 sheet aluminum at least 1/8" thick. Use natural aluminum cabinets. Perform all welding of aluminum and aluminum alloys in accordance with the latest edition of AWS D1.2, Structural Welding Code - Aluminum. Continuously weld the seams using Gas Metal Arc Welding (GMAW).

Slant the cabinet roof away from the front of the cabinet to prevent water from collecting on it.

Do not place a manufacturer name, logo, or other information on the faces of the controller cabinet visible to the motorist.

Provide cabinets capable of housing the components and sized to fit space requirement. Design the cabinet layout for ease of maintenance and operation, with all components easily accessible. Submit a cabinet layout plan for approval by the Engineer.

Locate louvered vents with filters in the cabinet to direct airflow over the controller and auxiliary equipment, and in a manner that prevents rain from entering the cabinet. Fit the inside of the cabinet, directly behind the vents, with a replaceable, standard-size, commercially available air filter of sufficient size to cover the entire vented area.

Provide a torsionally rigid door with a continuous stainless steel hinge on the side that permits complete access to the cabinet interior. Provide a gasket as a permanent and weather resistant seal at the cabinet door and at the edges of the fan / exhaust openings. Use a non-absorbent gasket material that will maintain its resiliency after long-term exposure to the outdoor environment. Construct the doors so that they fit firmly and evenly against the gasket material when closed. Provide the cabinet door with louvered vents and air filters near the bottom as described in the paragraph above.

Provide a Plexiglas rack of appropriate size at a convenient location on the inside of the door to store the cabinet wiring diagrams and other related cabinet drawings. Provide a Corbin #2 main door lock made of non-ferrous or stainless steel material. Key all locks on the project alike, and provide 10 keys to the Engineer. In addition, design the handle to permit pad-locking.

Provide the interior of the cabinet with ample space for housing the controller and all associated equipment and wiring; use no more than 75% of the useable space in the cabinet. Provide ample space in the bottom of the cabinet for the entrance and exit of all power, communications, and grounding conductors and conduit.

Arrange the equipment so as to permit easy installation of the cabling through the conduit so that they will not interfere with the operation, inspection, or maintenance of the unit. Provide adjustable

metal shelves, brackets, or other support for the controller unit and auxiliary equipment. Leave a 3 inch minimum clearance from the bottom of the cabinet to all equipment, terminals, and bus bars.

Provide power supply monitoring circuitry to detect power failure and to automatically report the occurrence to the Control Software.

Install two 15-watt fluorescent light strips with shields, one in the top of the cabinet and the other under the bottom shelf. Design both lights to automatically turn on when the cabinet door is opened and turn off when the door closes.

Mount and wire a 120V (±10%) GFCI duplex receptacle of the 3-wire grounding type in the cabinet in a location that presents no electrical hazard when used by service personnel for the operation of power tools and work lights.

No cabinet resident equipment may utilize the GFCI receptacle. Furnish one spare non-GFCI receptacle for future equipment.

Mount a bug-proof and weatherproof thermostatically controlled fan and safety shield in the top of the cabinet. Size the fan to provide at least for two air exchanges per minute. Fuse the fan at 125% of the capacity of the motor. The magnetic field of the fan motor must not affect the performance of the control equipment. Use a fan thermostat that is manually adjustable to turn on between 80°F and 160°F with a differential of not more than 10°F between automatic turn-on and turn-off. Mount it in an easily accessible location, but not within 6 inches of the fan.

Install additional fans and/or heaters as needed to maintain the temperature inside the cabinet within the operating temperature range of the equipment within the cabinet as recommended by equipment manufacturer(s).

1. Wiring

The requirements stated herein apply wherever electrical wiring is needed for any DMS system assemblies and subassemblies such as controller cabinet, DMS enclosure, electrical panel boards and etc.

Neatly arrange and secure the wiring inside the cabinet. Where cable wires are clamped to the walls of the control cabinet, provide clamps made of nylon, metal, plastic with rubber or neoprene protectors, or similar. Lace and jacket all harnesses, or tie them with nylon tie wraps spaced at 6 inches maximum to prevent separation of the individual conductors.

Individually and uniquely label all conductors. Ensure all conductor labels are clearly visible without moving the conductor. Connect all terminal conductors to the terminal strip in right angles. Remove excess conductor before termination of the conductor. Mold the conductor in such a fashion as to retain its relative position to the terminal strip if removed from the strip. Do not run a conductor across a work surface with the exception of connecting to that work surface. No conductor bundles can be support by fasteners that support work surfaces. Install all connectors, devices and conductors in accordance to manufactures guidelines. Comply with the latest NEC guideline in effect during installation. No conductor or conductor bundle may hang loose or create a snag hazard. Protect all conductors from damage. Ensure all solder joints are completed using industry accepted practices and will not fail due to vibration or movement. Protect lamps and control boards from damage.

No splicing will be allowed for feeder conductors and communication cables from the equipment cabinet to the DMS enclosure.

Insulate all conductors and live terminals so they are not hazardous to maintenance personnel.

Route and bundle all wiring containing line voltage AC and / or shield it from all low voltage control circuits. Install safety covers to prevent accidental contact with all live AC terminals located inside the cabinet.

Use industry standard, keyed-type connectors with a retaining feature for connections to the controller.

Label all equipment and equipment controls clearly.

Supply each cabinet with one complete set of wiring diagrams that identify the color-coding or wire tagging used in all connections. Furnish a water-resistant packet adequate for storing wiring diagrams, operating instructions, and maintenance manuals with each cabinet.

2. Power Supply and Circuit Protection

Design the DMS and controller for use on a system with a line voltage of 120V $\pm$ 10% at a frequency of 60 Hz $\pm$ 3 Hz. Under normal operation, do not allow the voltage drop between no load and full load of the DMS and its controller to exceed 3% of the nominal voltage.

Blackout, brownout, line noise, chronic over-voltage, sag, spike, surge, and transient effects are considered typical AC voltage defects. Protect the DMS system equipment so that these defects do not damage the DMS equipment or interrupt their operation. Equip all cabinets with devices to protect the equipment in the cabinet from damage due to lightning and external circuit power and current surges.

3. Circuit Breakers

Protect the DMS controller, accessories, and cabinet utilities with thermal magnetic circuit breakers. Provide the controller cabinet with a main circuit breaker sized according to the NEC. Use appropriately sized branch circuit breakers to protect the controller and accessories and for servicing DMS equipment and cabinet utilities.

4. Surge Suppressor

Install and clearly label filtering hybrid power line surge protectors on the load side of the branch circuit breakers in a manner that permits easy servicing. Ground and electrically bond the surge protector to the cabinet within 2 inches.

Provide power line surge protector that meets the following requirements:

Peak surge current occurrences	20 minimum
Peak surge current for an 8 x 20 microsecond waveshape	50,000 amperes
Energy Absorption	> 500 Joules
Clamp voltage	240 volts
Response time	<1 nanosecond
Minimum current for filtered output	15 amperes for 120VAC*
Temperature range	-40°F to +158°F

*Capable of handling the continuous current to the equipment

5. Radio Interference Suppressor

Provide each controller cabinet with sufficient electrical and electronic noise suppression to enable all equipment in it to function properly. Provide one or more radio interference suppressors (RIS) connected between the stages of the power line surge suppressor that minimize interference generated in the cabinet in both the broadcast and the aircraft frequencies. Each RIS must provide a minimum attenuation of 50 decibels over a frequency range of 200 KHz to 75 MHz. Clearly label the suppressor(s) and size them at least at the rated current of the main circuit breaker but not less than 50 amperes.

Provide RIS that are hermetically sealed in a substantial metal case which is filled with a suitable insulating compound and have nickel-plated 10/24 brass stud terminals of sufficient external length to provide space to connect #8 AWG wires. Mount them so that the studs cannot be turned in the case. Properly insulate ungrounded terminals from each other, and maintain a surface linkage distance of not less than ¼" between any exposed current conductor and any other metallic parts. The terminals must have an insulation factor of 100-200 MΩ, dependent on external circuit conditions. Use RIS designed for 120 VAC ± 10%, 60Hz, and which meet the standards of UL and the Radio Manufacturers Association.

6. Communications Surge Protector

Equip the cabinet with properly labeled hybrid data line surge protectors that meet the following general requirements:

Surge current occurrences at 2000 ampere, 8 x 20 microsecond waveform	> 80
Surge current occurrences at 400 ampere, 10x700 microsecond waveform	> 80
Peak surge current for 8 x 20 microsecond waveform	10,000 A (2500 A/line)
Peak surge current for 10x700 microsecond waveform	500 A/line
Response time	< 1 nanosecond
Series resistance	< 15 Ω
Average capacitance	1500 pF
Temperature range	-10°F to 150°F
Clamp Voltage	As required to match equipment in application

7. Lightning Arrester

Protect the system with an UL-approved lightning arrester installed at the main service disconnect that meets the following requirements:

Type of design	Silicon Oxide Varistor
Voltage	120/240 Single phase, 3 wires

Maximum current	100,000 amps
Maximum energy	3000 joules per pole
Maximum number of surges	Unlimited
Response time one milliamp test	5 nanoseconds
Response time to clamp 10,000 amps	10 nanoseconds
Response time to clamp 50,000 amps	25 nanoseconds
Leak current at double the rated voltage	None
Ground Wire	Separate

8. Uninterruptible Power Supply (UPS)

Provide the cabinet with an industrial grade power conditioning UPS unit to supply continuous power to operate the equipment connected to it if the primary power fails. The UPS must detect a power failure and provide backup power within 20 milliseconds. Transition to the UPS source from primary power must not cause loss of data or damage to the equipment being supplied with backup power. Provide an UPS with at least three outlets for supplying conditioned AC voltage to the DMS controller and modem. Provide a unit to meet the following requirements:

- Input Voltage Range: 120VAC +12%, -25%
- Power Rating: 1000 VA, 700 Watts
- Input Frequency: 45 to 65 Hz
- Input Current: 7.2A
- Output Voltage: 120VAC +/- 3%
- Output Frequency: 50/60 +/-1 Hz
- Output Current: 8.3A
- Output Crest Factor Ration: @50% Load Up to 4.8:1
  @75% Load Up to 3.2:1
  @100% Load Up to 2.4:1
- Output THD: 3% Max. (Linear)
  5% Max. (Non-Linear)
- Output Overload: 110% for 10 min; 200% for 0.05 sec.
- Output Dynamic Response: +/- 4% for 100% Step Load Change
- 0.5 ms Recovery Time.
- Output Efficiency @ 100% Load:90% (Normal Mode)
- Operating Temperature: -40 °F to +165 °F
- Humidity: 0% to 95% Non-condensing

- Remote Monitoring Interface: RS-232
- Protection: Input/Output Short Circuit
  Input/Output Overload
  Excessive Battery Discharge
- Specifications: UL1778, FCC Class A, IEEE 587

Provide the UPS unit capable of supplying 30 minutes of continuous backup power to the equipment connected to it when the equipment is operating at full load.

9. Controller Communications Interface

Provide the controller with the following interface ports:

An EIA/TIA-232E port for remote communication using NTCIP

An 10/100 Ethernet port for remote communication using NTCIP

An EIA/TIA-232E port for onsite access using a laptop

An EIA/TIA-232E auxiliary port for communication with a field device such as a UPS

Fiber Optic ports for communication with the sign

RJ45 ports for communication with the sign using CAT-5 cable

RJ45 ports for communication with mini-controller located inside the sign enclosure

10. Controller Local User Interface

Provide the controller with a Local User Interface (LUI) for at least the following functions:

On / Off Switch: controls power to the controller.

Control Mode Switch: for setting the controller operation mode to either remote or local mode.

LCD Display and Keypad: Allow user to navigate through the controller menu for configuration (display, communications parameter, etc) running diagnostics, viewing peripherals status, message creation, message preview, message activation, and etc. Furnish a LCD display with a minimum size of 240x64 dots with LED back light.

11. Controller Address

Assign each DMS controller a unique address. Preface all commands from the Control Software with a particular DMS controller address. The DMS controller compares its address with the address transmitted; if the addresses match, then the controller processes the accompanying data.

12. Controller Functions

Design the DMS controller to continuously control and monitor the DMS independent of the Control Software. Design the controller to display a message on the sign sent by the Control Software, a message stored in the sign controller memory, or a message created on-site by an operator using the controller keypad.

Provide the DMS controller with a watchdog timer to detect controller failures and to reset the microprocessor, and with a battery backed-up clock to maintain an accurate time and date reference. Set the clock through an external command from the Control Software or the Local User Interface.

13. DMS Controller Memory

Furnish each DMS controller with non-volatile memory. Use the non-volatile memory to store and reprogram at least one test pattern sequence and 500 messages containing a minimum of two pages of 45 characters per page. The Control Software can upload messages into and download messages from each controller's non-volatile memory remotely.

Messages uploaded and stored in the controller's non-volatile memory may be erased and edited using the Control Software and the controller. New messages may be uploaded to and stored in the controller's non-volatile memory using the Control Software and the controller.

14. Telephone Modem

Furnish and install industrial-grade modems with a data rate of 56 kbps. The modem must have a watchdog circuitry to continuously monitor the power supply, internal hardware, and operational software. In the event of a hardware or software problem, provide a modem that automatically resets itself.

15. Telephone Line Surge and Lightning Protector

Provide telephone line surge and lightning protectors that are UL rated for industrial use and meet the following specifications:

Technology	Solid state with fast acting fuses and resistors
Usage	Telephone Line
Ports Protected	1 (2 lines per port)
Connectors	RJ11/12
Surge Capacity	1.9 kA / line
Clamp & Rated Voltage	270 V and 200 V
Max Frequency	50 MHz
Operating Temperature	-40° F to 185 ° F
Max Inline Resistance	22 Ohms
Ratings	UL 497A, IEC801-5, CCITT (ITU-T) K17

E. Photo-Electric Sensors

Install three photoelectric sensors with ½ inch minimum diameter photosensitive lens inside the DMS enclosure. Use sensors that will operate normally despite continual exposure to direct sunlight. Place the sensors so they are accessible and field adjustable. Point one sensor north or bottom of the sign. Place the other two, one on the back wall and one on the front wall of the sign enclosure. Alternate designs maybe accepted, provided the sensor assemblies are accessible and serviceable from inside the sign enclosure.

Provide controls so that the Engineer can field adjust the following:

- The light level emitted by the pixels elements in each Light Level Mode.
- The ambient light level at which each Light Level Mode is activated.

F. Equipment List

Provide a general description of all equipment and all information necessary to describe the basic use or function of the major system components. Include a general "block diagram" presentation. Include tabular charts listing auxiliary equipment, if any is required. Include the nomenclature, physical and electrical characteristics, and functions of the auxiliary equipment unless such information is contained in an associated manual; in this case include a reference to the location of the information. Include an itemized list of equipment costs.

Include a table itemizing the estimated average and maximum power consumption for each major piece of equipment.

G. Physical Description

Provide a detailed physical description of size, weight, center of gravity, special mounting requirements, electrical connections, and all other pertinent information necessary for proper installation and operation of the equipment.

H. Parts List

Provide a parts list that contains all information needed to describe the characteristics of the individual parts, as required for identification. Include a list of all equipment within a group and a list of all assemblies, sub-assemblies, and replacement parts of all units. Arrange this data in a table, in alpha-numerical order of the schematic reference symbols, which gives the associated description, manufacturer's name, and part number, as well as alternate manufacturers and part numbers. Provide a table of contents or other appropriate grouping to identify major components, assemblies, etc.

I. Character Set Submittal

Submit an engineering drawing of the DMS character set including 26 upper case and lower case letters, 10 numerals, an asterisk (*), a dash, a plus sign (+), a designated lane diamond, a slash, an ampersand, and arrows at 0, 45, 90, 135, 180, 225, 270, and 315 degrees.

J. Wiring Diagrams

Provide a wiring diagram for each DMS and each controller cabinet, as well as interconnection wiring diagrams for the system as a whole.

Provide complete and detailed schematic diagrams to component level for all DMS assemblies and subassemblies such as driver boards, control boards, DMS controller, power supplies, and etc. Ensure that each schematic enables an electronics technician to successfully identify any component on a board or assemblies and trace its incoming and outgoing signals.

K. Routine of Operation

Describe the operational routine, from necessary preparations for placing the equipment into operation to securing the equipment after operation. Show appropriate illustrations with the sequence of operations presented in tabular form wherever applicable. Include in this section a total list of the test instruments, aids and tools required to perform necessary measurements and measurement techniques for each component, as well as set-up, test, and calibration procedures.

L. Maintenance Procedures

Specify the recommended preventative maintenance procedures and checks at pre-operation, monthly, quarterly, semi-annual, annual, and "as required" periods to assure equipment operates reliably. List specifications (including tolerances) for all electrical, mechanical, and other applicable measurements and / or adjustments.

M. Repair Procedures

Include in this section all data and step-by-step procedures necessary to isolate and repair failures or malfunctions, assuming the maintenance technicians are capable of analytical reasoning using the information provided in the section titled "Wiring Diagrams and Theory of Operation."

Describe accuracy, limits, and tolerances for all electrical, physical, or other applicable measurements. Include instructions for disassemblies, overhaul, and re-assemblies, with shop specifications and performance requirements.

Give detailed instructions only where failure to follow special procedures would result in damage to equipment, improper operation, danger to operating or maintenance personnel, etc. Include such instructions and specifications only for maintenance that specialized technicians and engineers in a modern electromechanical shop would perform. Describe special test set-up, component fabrication, and the use of special tools, jigs, and test equipment.

N. Field Trial

At the request of the Engineer, supply a three character demonstration module with characters of the size and type specified for the project, an appropriate control device and power supply to allow character display within 30 working days of the request. Perform a field trial on this module at a time and location selected by the Engineer.

This trial will allow the Engineer or his selected representatives to test the readability of the DMS at the maximum distance required for specified character size. Test the module with the sun directly above the DMS, and near the horizon in front of and behind the DMS (washout and back-lit conditions).

20.3. CONSTRUCTION METHODS

A. Description

This article establishes practices and procedures and gives minimum standards and requirements for the installation of Dynamic Message Sign systems, auxiliary equipment and the construction of related structures.

Provide electrical equipment described in this specification that conforms to the standards of NEMA, UL, or Electronic Industries Association (EIA), wherever applicable. Provide connections between controllers and electric utilities that conform to NEC standards. Express wire sizes according to the American Wire Gauge (AWG).

Provide stainless steel screws, nuts, and locking washers in all external locations. Do not use self-tapping screws unless specifically approved by the Engineer. Use parts made of corrosion-resistant materials, such as plastic, stainless steel, brass, or aluminum. Use construction materials that resist fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

B. Layout

The Engineer will establish the actual location of each Dynamic Message Sign assemblies. It is the Contractor's responsibility to ensure proper elevation, offset, and orientation of all DMS assemblies. The location of service poles as well as conduit lengths shown in the Plans, are approximate based on available project data. Make actual field measurements to place conduit and equipment at the required location. Submit a drawing showing all underground conduits and cables dimensioned from fixed objects or station marks.

C. Construction Submittal

When the work is complete, submit "as built" plans, inventory sheets, and any other data required by the Engineer to show the details of actual construction and installation and any modifications made during installation.

The "as built" plans will show: the DMS, controller, and service pole locations; DMS enclosure and controller cabinet wiring layouts; and wire and conduit routing. Include detailed drawings that identify the routing of all conductors in the system by cable type, color code, and function. Clearly label all equipment in the DMS system, controller cabinet, and DMS enclosure.

D. Conduit

Install the conduit system in accordance with section 1097 of Standard Specification and NEC requirements for an approved watertight raceway.

Make bends in the conduit so as not to damage it or change its internal diameter. Install watertight and continuous conduit with as few couplings as standard lengths permit.

Clean conduit before, during, and after installation. Install conduit in such a manner that temperature changes will not cause elongation or contraction that might damage the system.

Attach the conduit system to and install along the structural components of the DMS structure assemblies with beam clamps or stainless steel strapping. Install strapping according to the strapping manufacturer's recommendations. Do not use welding or drilling to fasten conduit to structural components. Space the fasteners at no more than 4 feet for conduit 1.5 inches and larger or 6 feet for conduit smaller than 1.25 inches. Place fasteners no more than 3 feet from the center of bends, fittings, boxes, switches, and devices.

Locate underground conduit as shown in the Plans in a manner consistent with these Project Special Provisions.

Do not exceed the appropriate fill ratio on all cable installed in conduit as specified in the NEC.

E. Wiring Methods

Do not pull permanent wire through a conduit system until the system is complete and has been cleaned.

Color-code all conductors per the NEC. Use approved marking tape, paint, sleeves or continuous colored conductors for No.8 AWG and larger. Do not mark a white conductor in a cable assemblies any other color.

Bury underground circuits at the depth shown in the Plans and surround it with at least 3 inches of sand or earth back-fill free of rocks and debris. Compact backfill in 6 inch layers. Do not splice underground circuits unless specifically noted in the Plans.

F. Equipment and Cabinet Mounting

Mount equipment securely at the locations shown in the Plans, in conformance with the dimensions shown. Install fasteners as recommended by the manufacturer and space them evenly. Use all mounting holes and attachment points for attaching DMS enclosures and controller cabinets to the structures.

Drill holes for expansion anchors of the size recommended by the manufacturer of the anchors and thoroughly clean them of all debris.

Provide one key-operated, pin tumbler, dead bolt padlock, with brass or bronze shackle and case, conforming to Military Specification MIL-P-17802E (Grade I, Class 2, Size 2, Style A) for each electrical panel and switch on the project. Key all padlocks alike, and provide 10 keys to the Engineer.

Provide cabinets with all mounting plates, anchor bolts, and any other necessary mounting hardware in accordance with these Project Special Provisions and the Plans.

Seal all unused conduit installed in cabinets at both ends to prevent water and dirt from entering the conduit and cabinet with approved sealing material.

Install a ground bushing attached inside the cabinet on all metal conduits entering the cabinet. Connect these ground bushings to the cabinet ground bus.

G. Work Site Clean-Up

Clean the site of all debris, excess excavation, waste packing material, wire, etc. Clean and clear the work site at the end of each workday. Do not throw waste material in storm drains or sewers.

20.4. Measurement and Payment

Walk-In Enclosure DMS will be measured and paid as the actual number of DMS furnished, installed, and accepted.

Each DMS consists of a LED Dynamic Message Sign, communications equipment, strapping hardware, controller, UPS, controller cabinet, conduit, fittings, couplings, sweeps, conduit bodies, wire, flexible conduit, power conductors and communications cable between the controller cabinet and the DMS enclosure, connectors, circuit protection equipment, photo-electric sensors, tools, materials, all related testing, cost of labor, cost of transportation, incidentals, and all other equipment necessary to furnish and install the DMS system.

Front Access Enclosure DMS will be measured and paid as the actual number of DMS furnished, installed, and accepted.

Each DMS consists of a LED Dynamic Message Sign, communications equipment, strapping hardware, controller, UPS, controller cabinet, conduit, fittings, couplings, sweeps, conduit bodies, wire, flexible conduit, power conductors and communications cable between the controller cabinet and the DMS enclosure, connectors, circuit protection equipment, photo-electric sensors, tools, materials, all related testing, cost of labor, cost of transportation, incidentals, and all other equipment necessary to furnish and install the DMS system.

Payment will be made under:

Walk-In Enclosure DMS ..... Each

Front Access Enclosure DMS ..... Each

21. NTCIP REQUIREMENTS

This section defines the detailed NTCIP requirements for the DMSs covered by these Project Special Provisions and Plans.

21.1. REFERENCES

This specification references several standards through their NTCIP designated names. The following list provides the full reference to the current version of each of these standards.

Implement the most recent version of the standard including any and all Approved or Recommended Amendments to these standards for each NTCIP Component covered by these project specifications.

Table 1: NTCIP Standards

Abbreviated Number	Full Number	Title
NTCIP 1101	**NTCIP 1101:1997**	*Simple Transportation Management Framework*
NTCIP 1201	**NTCIP 1201:1997**	*Global Object Definitions*
NTCIP 1203	**NTCIP 1203:1997**	*Object Definitions for Dynamic Message Signs*
NTCIP 2001	**NTCIP 2001:1997**	*Class B Profile*
NTCIP 2101	**NTCIP 2101**	*SP-PMPP/232* *Subnet Profile for PMPP over RS-232*
NTCIP 2102	**NTCIP 2102**	*SP-PMPP/FSK* *Subnet Profile for PMPP over FSK Modem*
NTCIP 2103	**NTCIP 2103**	*SP-PPP/232* *Subnetwork Profile for PPP over RS232 (Dial Up)*
NTCIP 2104	**NTCIP 2104**	*SP-Ethernet* *Subnet Profile for Ethernet*
NTCIP 2201	**NTCIP 2201**	*TP-Null* *Transport Profile*

NTCIP 2202	**NTCIP 2202**	*TP-Internet* *Internet Transport Profile (TCP/IP and UDP/IP)*
NTCIP 2301	**NTCIP 2301**	AP-STMF AP for Simple Transportation Management Framework

A. General Requirements

1. Subnet Level

Ensure each serial port on each NTCIP Component supports NTCIP 2103 over a dial-up connection with a contractor provided external modem with data rates of 28.8 kbps, 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps. Enable the NTCIP Component to make outgoing and receive incoming calls as necessary and support the following modem command sets:

- Hayes AT - Command Set
- MNP5
- MNP10
- V 42bis

Ensure each serial port on each NTCIP Component supports NTCIP 2103 over a null-modem connection with data rates of 19.2 kbps, 14.4 kbps, 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

Ensure each serial port on each NTCIP Component supports NTCIP 2101 with data rates of 9600 bps, 4800 bps, 2400 bps, 1200 bps, 600 bps, and 300 bps.

Ensure NTCIP components support NTCIP 2102 and NTCIP 2104.

NTCIP Components may support additional Subnet Profiles at the manufacturer's option. At any one time, make certain only one Subnet Profile is active on a given serial port of the NTCIP Component. Ensure the NTCIP Component can be configured to allow the field technician to activate the desired Subnet Profile and provide a visual indication of the currently selected Subnet Profile.

2. Transport Level

Ensure each NTCIP Component complies with NTCIP 2201 and 2202.

NTCIP Components may support additional Transport Profiles at the manufacturer's option. Ensure Response datagrams use the same Transport Profile used in the request. Ensure each NTCIP Component supports the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

3. Application Level

Ensure each NTCIP Component complies with NTCIP 1101 and 2301 and meets the requirements for Conformance Level 1 (NOTE - See Amendment to standard).

Ensure each NTCIP Component supports SNMP traps. An NTCIP Component may support additional Application Profiles at the manufacturer's option. Ensure Responses use the same Application Profile used by the request. Ensure each NTCIP Component supports the receipt of Application data packets at any time allowed by the subject standards.

4. Information Level

Guarantee each NTCIP Component provides Full, Standardized Object Range Support of all objects required by these Special Provisions unless otherwise indicated below. Make certain the maximum Response Time for any object or group of objects is 200 milliseconds.

Design the DMS to support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203. Table 2 indicates the modified object requirements for these mandatory objects.

Table 2: Modified Object Ranges for Mandatory Objects

Object	Reference	Project Requirement
ModuleTableEntry	NTCIP 1201 Clause 2.2.3	Contains at least one row with moduleType equal to 3 (software). The moduleMake specifies the name of the manufacturer, the moduleModel specifies the manufacturer's name of the component and the modelVersion indicates the model version number of the component.
MaxGroupAddresses	NTCIP 1201 Clause 2.7.1	At least 1
CommunityNamesMax	NTCIP 1201 Clause 2.8.2	At least 3
DmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	At least 1*
DmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	At least 21
DmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	At least 20 when no messages are stored.
DmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS supports any valid MULTI string containing any subset of those MULTI tags listed in Table 4
DmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Support at least the following modes:

		Local External central CentralOverride

* Ensure the Permanent Messages display the content shown in Table 3

Ensure the sign blanks if a command to display a message contains an invalid Message CRC value for the desired message.

Table 3: Content of Permanent Messages

Perm. Msg. Num.	Description
1	Permanent Message #1 blanks the display (i.e., consist of and empty MULTI string). It has a run-time priority of one (1).

Table 4: Required MULTI Tags

Code	Feature
f1	field 1 - time (12hr)
f2	field 2 - time (24hr)
f8	field 8 – day of month
f9	field 9 – month
f10	field 10 - 2 digit year
f11	field 11 - 4 digit year
fl (and /fl)	flashing text on a line by line basis with flash rates controllable in 0.5 second increments.
fo	Font
jl2	Justification – line – left
jl3	Justification – line – center
jl4	Justification – line – right
jl5	Justification – line – full
jp2	Justification – page – top
jp3	Justification – page – middle

jp4	Justification – page – bottom
Mv	moving text
Nl	new line
Np	new page, up to 2 instances in a message (i.e., up to 3 pages/frames in a message counting first page)
Pt	page times controllable in 0.5 second increments.

The NTCIP Component implements all mandatory and optional objects of the following optional conformance groups with FSORS.

5. Test Heading

(A) Time Management

As defined in NTCIP 1201

(B) Timebase Event Schedule

As defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 5: Modified Object Ranges for the Timebase Event Schedule Conformance Group

Object	Reference	Project Requirement
MaxTimeBaseScheduleEntries	NTCIP 1201 Clause 2.4.3.1	At least 28
maxDayPlans	NTCIP 1201 Clause 2.4.4.1	At least 14
maxDayPlanEvents	NTCIP 1201 Clause 2.4.4.2	At least 10

(C) Report

As defined in NTCIP 1201. The following list indicates the modified object requirements for this conformance group.

Table 6: Modified Object Ranges for the Report Conformance Group

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1201 Clause 2.5 1	At least 50
eventConfigurationMode	NTCIP 1201 Clause 2.4.3 1	The NTCIP Component supports the following Event Configuration Modes: onChange greaterThanValue smallerThanValue

MaxEventLogSize	NTCIP 1201 Clause 2.5.3	At least 200
MaxEventClasses	NTCIP 1201 Clause 2.5.5	At least 16

(D) PMPP

(E) Font Configuration

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 7: Modified Object Ranges for the Font Configuration Conformance Group

Object	Reference	Project Requirement
NumFonts	NTCIP 1203 Clause 2.4.1.1.1.1	At least 4*
MaxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	At least 127**

*Upon delivery, the first font is a standard 18" font. The second font is a double-stroke 18" font. The third font is a 28" font. The fourth font is empty.

**Upon delivery, the first three font sets are configured in accordance with the ASCII character set for the following characters:

- "A" thru "Z"- All upper case letters.
- "0" thru "9"- All decimal digits.
- Space (i.e., ASCII code 0x20).
- Punctuation marks shown in brackets [. , ! ? - ' ' " " / ( )]
- Special characters shown in brackets [# & * +< >]

(F) DMS Configuration

As defined in NTCIP 1203.

(G) MULTI Configuration

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 8: Modified Object Ranges for the MULTI Configuration Conformance Group

Object	Reference	Project Requirement
DefaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS supports the following background colors: black
DefaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS supports the following foreground colors:

		amber
DefaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The DMS supports the following forms of line justification: left center right full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1 7	The DMS supports the following forms of page justification: top middle bottom
defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1 1.8	The DMS supports the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1 1.9	The DMS supports the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	The DMS supports the following character sets: eightBit

(H) Default Message Control **as defined in NTCIP 1203**

(I) Pixel Service Control **as defined in NTCIP 1203**

(J) MULTI Error Control **as defined in NTCIP 1203**

(K) Illumination/Brightness Control

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 9: Modified Object Ranges for the Illumination/Brightness Control Conformance Group

Object	Reference	Project Requirement
dmsIllumControl	NTCIP 1203 Clause 2.8.1.1.1.1	The DMS supports the following illumination control modes: photocell timer

		manual
dmsIllumNumBrightLevels	NTCIP 1203 Clause 2.8.1.1.1.4	At least 16

(L) Auxiliary I/O

(M) Scheduling

As defined in NTCIP 1203. The following list indicates the modified object requirements for this conformance group.

Table 10: Modified Object Ranges for the Scheduling Conformance Group

Object	Reference	Project Requirement
NumActionTableEntries	NTCIP 1203 Clause 2.9.1.1.1.1	At least 21

(N) Sign Status **as defined in NTCIP 1203**

(O) Status Error **as defined in NTCIP 1203**

(P) Pixel Error Status **as defined in NTCIP 1203**

(Q) Fan Error Status **as defined in NTCIP 1203**

(R) Power Status as **defined in NTCIP 1203**

(S) Temperature Status **as defined in NTCIP 1203**

Install necessary hardware for the support of items q, r, and s above.

Table 11: Some Optional Object Requirements

Object	Reference	Project Requirement
DefaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The DMS supports the full range of these objects with step sizes no larger than 0.5 seconds
DefaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The DMS supports the full range of these objects with step sizes no larger than 0.5 seconds
DmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall provide meaningful error messages within this object whenever one of these tags generates an error.

6. Documentation

Supply software with full documentation, including a CD-ROM containing ASCII versions of the following MIB files in Abstract Syntax Notation 1 (ASN.1) format:

- The relevant version of each official standard MIB Module referenced by the device functionality
- If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro. Name this file identical to the standard MIB Module, except that it will have the extension ".man"
- A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- A MIB containing any other objects supported by the device.

Allow the use of any and all of this documentation by any party authorized by the Department for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

B. NTCIP Acceptance Testing

Test the NTCIP requirements outlined above by a third party testing firm. Submit to the Engineer for approval a portfolio of the selected firm. Include the name, address, and a history of the selected firm in performing NTCIP testing along with references. Also provide a contact person's name and phone number. Submit detailed NTCIP testing plans and procedures, including a list of hardware and software, to the Engineer for review and approval 10 days in advance of a scheduled testing date. Develop test documents based on the NTCIP requirements of these Project Special Provisions. The acceptance test will use the NTCIP Exerciser, and/or other authorized testing tools and will follow the guidelines established in the ENTERPRISE Test Procedures. Conduct the test in North Carolina on the installed system in the presence of the Engineer. Document and certify the results of the test by the firm conducting the test and submit the Engineer for review and approval. In case of failures, remedy the problem and have the firm retest in North Carolina. Continue process until all failures are resolved. The Department reserves the right to enhance these tests as deemed appropriate to ensure device compliance.

21.2. Measurement and Payment

There will be no direct payment for the work covered by this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for the DMS and will be full compensation for all work listed above.

22. DMS TESTING REQUIREMENTS

22.1. General Test Procedure

Test the DMS system in a series of design approval and functional tests. The results of each test must meet the specified requirements. These tests should not damage the equipment. The Engineer will reject equipment that fails to fulfill the requirements of any test. Resubmit rejected equipment after correcting non-conformities and re-testing; completely document all diagnoses and corrective actions. Modify all equipment furnished under this contract, without additional cost to the North Carolina Department of Transportation, to incorporate all design changes necessary to pass the required tests.

Provide 4 copies of all test procedures and requirements to the Engineer for review and approval at least 30 days prior to the testing start date.

Only use approved procedures for the tests. Include the following in the test procedures:

- A step-by-step outline of the test sequence, showing a test of every function of the equipment or system tested
- A description of the expected nominal operation, output, and test results, and the pass / fail criteria
- An estimate of the test duration and a proposed test schedule
- A data form to record all data and quantitative results obtained during the test
- A description of any special equipment, setup, manpower, or conditions required by the test

Provide all necessary test equipment and technical support. Use test equipment calibrated to National Institute of Standards and Technology (NIST) standards. Provide calibration documentation upon request. Conform to these testing requirements and the requirements of these specifications. The Engineer will reject all equipment not tested according to these requirements. It is the Contractor's responsibility to ensure the DMS system functions properly even after the Engineer accepts the DMS test results.

Provide 4 copies of the quantitative test results and data forms containing all data taken, highlighting any non-conforming results and remedies taken, to the Engineer for approval. An authorized representative of the manufacturer must sign the test results and data forms.

22.2. Design Approval Tests

Design Approval Tests are applicable to DMS systems not currently on the QPL.

The Design Approval Tests consists of all tests described in Section 2.2 "DMS Equipment Tests" of NEMA TS 4-2005 (Hardware Standards for Dynamic Message Signs with NTCIP Requirements). Perform all tests and submit certified results for review and approval.

PROTOTYPE – Manufacture a prototype DMS and controller of the type and size described in the Project Special Provisions. In the presence of the Engineer, test the prototype according to the Design Approval and Operational Tests. When all corrections and changes (if any) have been made, the Department may accept the prototype DMS and controller as the physical and functional

standard for the system furnished under this contract. You may use the prototype units on this project if, after inspection and rework (if necessary), they meet all physical and functional specifications. In the case of standard product line equipment, if the Contractor can provide test results certified by an independent testing facility as evidence of prior completion of successful design approval tests, then the Engineer may choose to waive these tests.
In each Design Approval Test, successfully perform the Functional Tests described below. Apply the extreme conditions to all associated equipment unless stated otherwise in these Project Special Provisions.

22.3. Operational Field Test (On-Site Commissioning)

Conduct an Operational Field Test of the DMS system installed on the project in the presence of the Engineer to exercise the normal operational functions of the equipment. The Operational Field Test will consist of the following tests as a minimum:

A. Physical Examination

Examine each piece of equipment to verify that the materials, design, construction, markings, and workmanship comply with the mechanical, dimensional, and assemblies requirements of these Project Special Provisions.

Perform the following tests as a minimum:

Verify that all surfaces are free of dents, scratches, weld burns, or abrasions. Round sharp edges and corners.

Verify bend radius of cables is not excessive or could potentially cause damage.

Verify all modules, lamps, and components are properly secured.

Verify that there are no exposed live terminals.

B. Continuity Tests

Check the wiring to assure it conforms to the requirements of these Project Special Provisions.

C. Functional Tests

Perform the following functional tests:

Start-up and operate the DMS locally using a laptop computer.

Use automatic (photo-electric sensor controlled) DMS Control Software to switch between "dim", "normal", and "bright" light levels.

Operate the DMS with all display elements flashing continuously for 10 minutes at the maximum flash rate.

Exercise the DMS by displaying static messages, flashing messages, and alternating static and flashing message sequences.

Automatic poll the DMS by the Control Software at various intervals and verify the data received by Control Software from DMS.

Download and edit messages using Control Software.

Execute status request on the DMS controller.

Observe normal operations during uploading and downloading messages.

Input and select messages from the sign controller's local user interface.

Test sequence activation at chosen intervals.

Display and verify all stored messages.

Verify resumption of standard operation upon interruption of electrical power.

Demonstrate detected failures and response functions.

Demonstrate proper operation of the Failure Log.

Set controller clock using the Control Software.

Execute system shutdown using the Control Software and local user interface.

Verify detection of a power failure in the DMS enclosure and the report feature of the failure to the Control Software.

Approval of Operational Field Test results does not relieve the Contractor to conform to the requirements in these Project Special Provisions. If the DMS system does not pass these tests, document a correction or substitute a new unit as approved by the Engineer. Re-test the system until it passes all requirements.

22.4. 60-Day Observation Period

The 60-Day Observation Period is part of work to be completed by the project completion date.

Upon successful completion of all project work, the component tests, the System Test, and the correction of all deficiencies, including minor construction items, the 60-day Observation Period may commence. This observation consists of a 60-day period of normal, day-to-day operations of the new field equipment in operation with the new central equipment without any failures. The purpose of this period is to ensure that all components of the system function in accordance with the Plans and these Project Special Provisions.

Respond to system or component failures (or reported failures) that occur during the 60-day Observation Period within twenty-four (24) hours. Correct said failures within forty-eight (48) hours. Any failure that affects a major system component as defined below for more than forty-eight (48) hours will suspend the timing of the 60-day Observation Period beginning at the time when the failure occurred. After the cause of such failures has been corrected, timing of the 60-day Observation Period will resume. System or component failures that necessitate a redesign of any component or failure in any of the major system components exceeding a total of three (3) occurrences, will terminate the 60-day Observation Period and cause the 60-day Observation Period to be restarted from day zero when the redesigned components have been installed and/or the failures corrected. The major system components are:

- DMS Field Controller
- DMS Display Module
- DMS Workstation software

22.5. Measurement and Payment

There will be no direct payment for the work covered in this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for the DMS and will be full compensation for all work covered in this section.

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23. DMS ASSEMBLIES

23.1 DESCRIPTION

This section includes all design, fabrication, furnishing, and erection of the DMS assemblies; ladders and walkways for access to the DMS inspection door and attachment of the DMS enclosures to the structures in accordance with the requirements of these Project Special Provisions and the *Standard Specifications*. Fabricate the supporting DMS assemblies from tubular steel. Furnish pedestal or span type DMS assemblies (walk-in and front access). Mount DMS on four (4) chord (box) truss. Cantilevered and Monotube (horizontal truss) DMS structures will not be allowed.

Provide the pedestal structure with a minimum of 25 feet and span structure with a minimum of 20 feet clearance from the high point of the road to the bottom of the DMS enclosure. The DMS assembly must allow for field adjustment (horizontal & vertical tilting) of the DMS enclosure to ensure optimum legibility from all travel lanes.

Design the new DMS assemblies and walkway, including footings, and submit shop drawings for approval. Design new walkways for existing DMS structures and submit shop drawings for approval. A Professional Engineer that is registered in the state of North Carolina will prepare such computations and drawings. These must bear his signature, seal, and date of acceptance.

It is the Contractor's responsibility to field verify the S-dimensions and determine the length and height of each DMS assembly.

The provisions of Section 900 of the Standard Specifications apply to all work covered by this section.

23.2 MATERIAL

Use materials that meet the following requirements of the Standard Specifications:

Structural Steel	Section 1072
Overhead Structures	Section 1096
Signing Materials	Section 1092
Organic-Zinc Repair Paint	Article 1080-9
Reinforcing Steel	Sub-article 1070
Direct Tension Indicators	Sections 440 and 1072

23.3 CONSTRUCTION METHODS

A. General

Fabricate the new DMS assemblies, ladders and walkways in accordance with the details shown in the approved shop drawings and the requirements of these Project Special Provisions.

No welding, cutting, or drilling in any manner will be permitted in the field, unless approved by the Engineer.

Drill bolt holes and slots to finished size. Holes may also be punched to finished size, provided the diameter of the punched holes are at least twice the thickness of the metal being punched. Flame cutting of bolt holes and slots is not permitted.

Erect DMSs in accordance with the requirements indicated on the plans and in these Project Special Provisions. Field drill two holes per connection in the Z bars for attaching DMS to structures. Use two bolts at each connection. Provide two (2) U-bolts at each U-bolt connection such as 1) each truss chord to sign hanger, or 2) each truss chord to walkway support. Provide two (2) U-bolts at each U-bolts connection where ends of truss chords are supported. Minimum diameter of all U-bolts is to be ½ inch.

Use two coats of a zinc-rich paint to touch up minor scars on all galvanized materials. See Standard Specifications for Roads and Structures Section 1076-6.

For high strength bolted connections, provide direct tension indicator washer.

B. Shop Drawing

Submit to the Engineer for approval a complete design for the DMS assemblies, including footings, DMS assembly hardware, brackets for supporting the DMS, ladder, access platform, and the maintenance walkway. Base design upon the final structure line drawings, wind load area and the wind speed shown on the plans, and in accordance with the "Standard Specifications for Structural Structures for Highway Signs, Luminaires and Traffic Signals."

The manufacturer of the DMS assembly must ensure that design of each assembly is compatible with the DMSs for mounting and attachment.

Submit six copies of complete detailed shop drawings and one copy of the design computations for the DMS assemblies to the Engineer for approval prior to fabrication. Show in the shop drawings complete design and fabrication details including foundations, provisions for attaching the DMS, ladder, access platform, and maintenance walkway to supporting structures, applicable material specifications, and any other information necessary for procuring and replacing any part of the complete DMS assemblies.

Allow a minimum of 40 working days for shop drawing approval after the Engineer receives them. If revised drawings are necessary, allow appropriate additional time for review and approval of final shop drawings.

Approval of shop drawings by the Engineer will not relieve the Contractor of his responsibility for the correctness of drawings, or for the fit of all shop and field connections and anchors, including but not limited to the installation of new walkways and existing structures.

C. Design and Fabrication

1. Dynamic Message Sign Assembly

The following criteria govern the design of DMS assemblies:

- Design must be in accordance with the Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition, 2001, and the latest Interim Specifications.
- The wind pressure map that is developed from the 3-second gust speeds, as provided in Article 3.8, shall be used.

- The natural wind gust speed in North Carolina shall be assumed to be 5 meters per second or 11.6 mph for inland areas, and 7 meters per second or 15.7 mph for coastal areas. The coastal area shall be defined as any area within 2 miles from the waterfront facing the ocean or sound and all area where the design basic wind speed is above 120 mph, as shown in Figure 3-2.
- The fatigue importance category used in the design, for each type of structure, as provided for in Article 11.6, Fatigue Importance Factors, shall be Category II unless otherwise shown on the contract plans.
- Wind drag coefficient for Dynamic Message Sign enclosures shall be 1.7.

The following Specification interpretations or criteria shall be used in the design of overhead sign assemblies:

- For design of supporting upright posts or columns, the effective length factor for columns "K", as provided for in Appendix B, Section B.5, shall be taken as the following, unless otherwise approved by the Engineer:

  Case 1 For a single upright post of span type overhead sign structure, the effective column length factor, "K", shall be taken as 2.0.

  Case 2 For twin post truss-type upright post with the post connected to one chord of a horizontal truss, the effective column length factor for that column shall be taken as 2.0.

  Case 3 For twin post truss-type upright post with the post connected to two truss chords of a horizontal tri-chord or box truss, the effective column length factor for that column shall be taken as 1.65.

- For twin post truss-type upright post, the unbraced length shall be from the chord to post connection to the top of base plate.
- For twin post truss-type upright post that is subject to axial compression, bending moment, shear, and torsion the post shall satisfy Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals Equations 5-17, 5-18 and 5-19. To reduce the effects of secondary bending, in lieu of Equation 5-18, the following equation may be used:

$$\frac{f_a}{F_a} + \frac{f_b}{\left(1 - \frac{0.6 f_a}{F_e}\right) F_b} + \left(\frac{f_v}{F_v}\right)^2 \leq 1.0$$

  Where
  fa = Computed axial compression stress at base of post

- The base plate thickness for all uprights and poles shall be a minimum of 2" but not less than that determined by the following criteria and design.

Case 1 Circular or rectangular solid base plates with the upright pole welded to the top surface of base plate with full penetration butt weld, and where no stiffeners are provided. A base plate with a small center hole, which is less than 1/5 of the upright diameter, and located concentrically with the upright pole, may be considered as a solid base plate.

The magnitude of bending moment in the base plate, induced by the anchoring force of each anchor bolt shall be calculated using equation $M = (P \times D_1) / 2$.

Case 2 Circular or rectangular base plate with the upright pole socketed into and attached to the base plate with two lines of fillet weld, and where no stiffeners are provided, or any base plate with a center hole that is larger in diameter than 1/5 of the upright diameter.

The magnitude of bending moment induced by the anchoring force of each anchor bolt shall be calculated using equation $M = P \times D_2$.

- M, bending moment at the critical section of the base plate induced by one anchor bolt
- P, anchoring force of each anchor bolt
- D_1, horizontal distance between the center of the anchor bolt and the outer face of the upright, or the difference between the radius of the bolt circle and the outside radius of the upright
- D_2, horizontal distance between the face of the upright and the face of the anchor bolt nut

- The critical section shall be located at the face of the anchor bolt and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections shall be considered ineffective.
- The thickness of base plate of Case 1 shall not be less than that calculated based on formula for Case 2.
- Uprights, foundations, and trusses shall be designed in accordance with the Overhead Sign Foundation Special Provision for the effects of torsion. Torsion shall be considered from dead load eccentricity of these attachments, as well as for attachments such as walkways, supporting brackets, etc., that add to the torsion in the assembly. Truss vertical and horizontal truss diagonals in particular and any other assembly members shall be appropriately sized for these loads.
- Uprights, foundations, and trusses shall be designed for the proposed sign wind area and future wind areas. The design shall consider the effect of torsion induced by the eccentric force location of the center of wind force above (or below) the center of the supporting

truss. Truss vertical and horizontal truss diagonals in particular and any other assembly members shall be appropriately sized for these loads.

Fabricate the supporting structures using tubular members of either aluminum or steel, using only one type of material throughout the project.

Horizontal components of the supporting structures for overhead DMS must be of a truss design to support the DMS. Truss centerline must coincide with centerline of the DMS design area shown on the structure line drawing. Provide permanent camber in addition to dead load camber in accordance with the "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals." Indicate on the shop drawings the amount of camber provided and the method employed in the fabrication of the support to obtain the camber.

For all U-bolt connections of hanger beams to overhead assembly truss chords, provide all U-bolts with a flat washer, a lock washer and double nuts at each end of the U-bolts. All double nuts that are on any U-bolt shall be the same thickness and weight. When assembled, the double nuts shall be brought tight against each other by the use of two wrenches.

Fabricate attachment assemblies for mounting DMSs in a manner that allows easy removal of the sign.

2. DMS Access Platform for Pedestal Structure

Provide an access platform, a minimum of three feet wide with open skid-resistant surface and safety railing on **pedestal structure** for access to the DMS inspection door. Provide platforms with fixed safety railings along both sides from the beginning of the platform to the inspection door.

Ensure the design, fabrication and installation of the access platforms on new DMS structures complies with the following:

1. The top of the platform grading surface is vertically aligned with the bottom of the DMS door.
2. The DMS door will open 90-degrees from its closed position without any obstruction from the platform or safety handrails.
3. The platform is rigidly and directly connected to the walkway brackets and there is no uneven surface between sections.
4. Install a 4" x 4" safety angle parallel to and along both sides of the platform and extend it the entire length of the platform. Design the safety angle to withstand loading equivalent to the platform.
5. Ensure the platform design allows full access to the DMS enclosure inspection door with no interference or obstructions.

3. DMS Walkway for Span Structure

Provide a maintenance walkway on **span structures**, a minimum of three feet wide, with open skid-resistant surface and safety railings on the DMS assemblies for access to the DMS inspection door. Provide a maintenance walkway that extends from the DMS inspection door to three feet over the edge of the shoulder. Provide new walkways with fixed safety railings along both sides from the beginning of the walkway to the inspection door.

Ensure the maintenance walkway complies with the following:

1. The top of the walkway grading surface is vertically aligned with the bottom of the DMS door with no gap between the end of the walkway and the DMS door.
2. The DMS door will open 90-degrees from its closed position without any obstruction from the walkway or safety handrails.
3. The walkway is rigidly and directly connected to the walkway brackets and there is no uneven surface between sections.
4. Install a 4" x 4" safety angle parallel to and along both sides of the platform and extend it the entire length of the platform. Design the safety angle to withstand loading equivalent to the platform.
5. Ensure the walkway design allows full access to the DMS enclosure inspection door with no interference or obstructions.

4. DMS Access Ladder

Provide a fixed ladder, of the same material as the **pedestal structure**, leading to the access platform. Equip the ladder with a security cover (ladder guard) and lock to prohibit access by unauthorized persons. Start the first ladder rung no more than 18 inches above finished ground and end it at the access platform. Design the rungs on 12-inch center to center typical spacing. Attach the security cover approximately 6 feet above the finished ground. Design the ladder and security cover as a permanent part of the DMS assembly and include complete design details in the DMS assembly shop drawings. Fabricate the ladder and cover to meet all OSHA requirements and applicable state and local codes, including but not limited to providing a ladder cage. Attached the bottom of the ladder to a concrete pad a minimum of 4 inches deep, 24 inches wide, and 36 inches long.

5. Anchor Rod Assembly

Attach the DMS structure to concrete foundations by the use of straight galvanized anchor rods with galvanized heavy hex nuts and flat washers. The rods, nuts and flat washers shall be galvanized in accordance with AASHTO M232. Provide anchor rods that have an anchor plate or flat washers with nut at the end to be embedded in concrete. For pedestal structures, use a minimum of eight anchor rods.

Ensure material used in steel anchor rods conforms to AASHTO M 314 or ASTM F1554, and the specified yield strength does not exceed 55,000 psi. Compute the required projection of the anchor rod above the foundation top. Compute the total projection based on the following:

- Provide between 3 and 5 threads of anchor rod projection above the top nut after tightening is complete. Avoid any additional projection, or a normal depth socket torque wrench shall not be used on top nuts.
- Include the sum of the thickness of top nut, top nut flat washer or top nut beveled washers, base plate, leveling nut flat washer or leveling nut beveled washers, leveling nut.

- Set the maximum distance between the bottom of the leveling nut and the foundation top to one nut height to avoid excessive bending stresses in the anchor rod under service conditions.
- Do not use lock washers.

6. Anchor Rod Nut Tightening Requirements for Metal Poles

a. Prior to installation

Protect the anchor rod threads from damage prior to installation and during installation.

Prior to installation of the rods in the foundation, turn nuts onto and off the rods, well past the elevation of the bottom of the leveling nuts. Turn by the effort of one worker using an ordinary wrench without a cheater bar. Report any thread damage to the Engineer.

b. During installation

1. Place leveling nuts (bottom nuts) on the anchor rods.

2. Place leveling nut washers on top of the anchor rod leveling nuts.

3. Place a rigid template on top of the leveling nuts to check the level of the nuts. Use beveled washers if the anchor nut and washer cannot be brought into firm contact with the template.

4. Verify that the distance between the bottom of the leveling nut and the top of the concrete foundation is no more than one anchor rod diameter. If an upright is required to be back-raked, then the distance between the bottom of the leveling nut and the top of the concrete foundation should be no more than one anchor rod diameter, averaged over the anchor rod group.

5. Place the base plate and structural element to which it is attached. However, do not attach to the upright element, during tightening of the anchor nuts, cantilever beams or arms with span in excess of 10 feet.

6. Place top nut washers.

7. Do not use lock washers.

8. Lubricate threads and bearing surfaces of top nuts with beeswax, stick paraffin, or other approved lubricant.

9. Place top nuts. Use beveled washers if the anchor nut and washer cannot be brought into firm contact with the base plate.

10. Tighten top nuts to snug tight. A snug-tight condition is defined as the washer and nut being in full contact with the base plate, and the application of the full effort of a workman on a 12-in wrench. Turn top nuts in increments following a star pattern (using at least two full tightening cycles).

11. To ensure proper pre-tensioning, after all top nuts have been brought to snug-tight condition, repeat the procedure on the leveling nuts. Turn leveling nuts in increments following a star pattern (using at least two full tightening cycles).

12. At this point, verify if beveled washers are required. Beveled washers are necessary under the leveling nut or top nut if any face of the base plate has a slope greater than 1:20 and/or any nut can not be brought into firm contact with the base plate.

13. Before further nut turning, make the reference position of the nut in the snug-tight condition with a suitable making (ink or paint that is not water-soluble). Mark on the corner at the intersection of two flats with a corresponding reference mark on the plate at each nut. After tightening, verify the nut rotation.

14. Achieve pre-tensioning by turn-of-nut method. Turn the top nuts to 1/6 of a turn. Do so in a star pattern using at least two full-tightening cycles.

15. After installation, ensure that firm contact exists between the anchor rod nuts, washers, and base plate on any anchor rod installed.

16. For overhead DMS assemblies: The span type truss may be placed on the uprights or attached to the upright at this time.

17. After a period of no less than 4 days, and no more than 2 weeks, and in the presence of the Engineer, use a torque wrench to verify that a torque at least equal to 600 foot-pounds is provided on each top nut. For DMS pedestal structures, verify the torque after erection of the remainder of the structure and attaching the DMS to the structure.

18. If any top nut torque reveals less than 600 foot-pounds of effort is required to move the nut, then tighten the nut to no less than 600 foot-pounds.

19. Calibrate the torque indicator on the wrench used for tightening the nuts annually if the project construction extends over a 12 month period. Provide the Engineer with certification of the calibration.

20. Do <u>not</u> place grout under the base plate.

23.4 MEASUREMENT AND PAYMENT

(____) structure for (____) DMS will be measured and paid as the actual number of dynamic message sign assemblies furnished, installed, and accepted. Payment includes all design, fabrication, construction, transportation, and attachment of the complete dynamic message sign assemblies, supporting structure, hardware, access platform or walkway, direct tension indicators, preparing and furnishing shop drawings, additional documentation, incidentals, and all other equipment and features necessary to furnish the system described above.

DMS Access Ladder will be measured and paid as the actual number of DMS access ladders furnished, installed and accepted. Payment includes design, fabrication, transportation, and attachment to the DMS assembly as described above.

Payment will be made under:

Pay Item

Pedestal Type Structure for Walk-In DMS.....Each

Pedestal Type Structure for Front Access DMS.....Each

Full Span Overhead Structure for Walk-In DMS ..... Each

DMS Access Ladder ..... Each

24. DMS FOUNDATION

24.1. DESCRIPTION

This section consists of the design and construction of DMS foundations in accordance with the submitted, approved plans and the requirements of these Project Special Provisions. Design and construct either spread footing type foundations and/or drilled pier type foundations for each DMS unless otherwise directed by the Engineer.

24.2. MATERIAL

Portland Cement Concrete Production and Delivery ..... Section 1000
Reinforcing Steel ..... Section 1070
Anchor Bolts ..... Article 1072-6
Structural Steel and Overhead Sign Structures ..... Section 1072 and 1096

24.3. CONSTRUCTION METHODS

A. General

A North Carolina Licensed Professional Engineer must seal all design calculations, drawings and recommendations. Design foundations for the effects of dead, wind and ice loads in accordance with the wind zone load shown in the Plans and Section 3 of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (including interims). Use either spread footing or drilled pier foundations. In some instances, conflicts with drainage structures may dictate a certain type of foundation. Spread footings or dual drilled pier foundations are required for full span overhead signs (no single drilled pier foundations). When designing dual drilled pier foundations, a rectangular grade beam with a moment of inertia approximately equal to either of the drilled piers is required to connect the pier tops.

Provide reinforced concrete design in accordance with either Section 13.7.2 or 13.6.2 (whichever is applicable), allowable stress design method, of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (including interims).

Consider sloping ground in the design, if applicable. Do not exceed an allowable bearing pressure of 3 ksf for spread footings. For drilled pier foundations, do not exceed an allowable lateral soil pressure of 4 ksf for AASHTO Group II Loading. Use the following default soil parameters and groundwater elevation for foundation design in the absence of a site-specific subsurface investigation in accordance with this provision.

Total Unit Weight = 120 pcf

Friction Angle = 30 degrees

Cohesion = 0 psf

Assume the groundwater elevation is at a depth of 7 feet below the ground surface. If the groundwater is encountered at a depth shallower than 7 feet, the overhead sign foundation must be redesigned based upon the actual field conditions. The default soil parameters and allowable pressures do not apply to very soft or loose soil, muck (generally, SPT blow counts per foot less than 4), weathered rock or hard rock (generally, SPT refusal). If soft or loose soil, muck, weathered rock or hard rock conditions are present, a site-specific subsurface investigation and foundation design is required in accordance with this provision.

Design spread footings in accordance with Sections 4.4.1 through 4.4.10, allowable stress design method, of the AASHTO Standard Specifications for Highway Bridges (including interims). Restrict uplift due to the eccentricity of the loading to one corner of the footing and the tension area may not exceed 25% of the total bearing area of the spread footing.

Design drilled piers in accordance with Sections 4.6.1 through 4.6.5, allowable stress design method, of the AASHTO Standard Specifications for Highway Bridges (including interims). If drilled piers are designed for skin friction only, increase the required length of each drilled pier a minimum of 6 inches to allow for sediment. If drilled piers are designed for end bearing, no additional length is required; however, the drilled piers will be subject to the cleanliness requirements in Section B under "Drilled Pier Construction:" below. Clearly state in the Plans whether end bearing was accounted for in the foundation design.

Calculate expected vertical, lateral and torsional movements for single drilled pier foundations. Provide drilled pier foundations that result in a horizontal lateral movement of less than 1 inch at the top of the pier and a horizontal rotational movement of less than 1 inch at the edge of the pier. Also, use a factor of safety of 2.0 for lateral and torsion failure. Preliminary design methods described in Section 13.6.1.1 of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (including interims) may be used to incorporate a factor of safety in foundation design for lateral failure. Wings are required to increase torsion resistance for cantilever signs supported by a single drilled pier.

If a site-specific subsurface investigation is performed, use only a NCDOT Pre-Qualified Geotechnical Engineering Firm to provide a site specific foundation design.

B. Subsurface Investigation

If the default soil parameters or allowable pressures referenced above are not applicable for a given overhead sign foundation site, the Engineer may require a site-specific subsurface investigation. If the Engineer requires a site-specific subsurface investigation, the Department will perform the borings and provide the data to the Contractor. The subsurface investigation will be provided within two weeks of being notified by the Contractor that the site is at rough grade and accessible to a drill rig.

The Contractor may elect to conduct a site specific subsurface investigation at each proposed overhead sign foundation location in accordance with the requirements listed below, in lieu of using the default soil parameters and allowable pressures referenced above. If the Contractor elects to conduct a site-specific subsurface investigation, the costs of the investigation will be considered incidental to the "Footings for DMS-_Structure" pay item.

Perform a boring at each overhead sign foundation location and provide boring data on an NCDOT Standard Boring Log form. Download this form from the NCDOT site at http://www.ncdot.org/doh/preconstruct/highway/geotech/contractserv/investigation/Documents/BoringLogs.zip. A licensed geologist or a professional engineer registered in the State of North Carolina and employed by an NCDOT Highway Design Branch pre-qualified Geotechnical Engineering Firm must seal each boring log. Use only an NCDOT Highway Design Branch pre-qualified Geotechnical Engineering Firm to conduct the subsurface investigation. Perform the investigation only after rough grade (within 3 feet of final grade) is achieved. Locate each boring within 3 feet of the center of the overhead sign foundation. Drill the boring to a minimum depth of 10 feet below the required spread footing bearing or drilled pier tip elevation, whichever is deeper. Conduct Standard Penetrating Tests at 1 ft, 2.5 ft, 5 ft, 7.5 ft, 10 ft, and every 5-ft after 10 ft below the rough grade in

accordance with ASTM D-1586. A boring may be terminated above the minimum depth required (10 ft below the foundation elevation) if one of the following conditions occur: (a) a total of 100 blows have been applied in any 2 consecutive 6-in.intervals; (b) a total of 50 blows have been applied with less than 3" penetration.

C. Foundation Construction

Excavate footings for overhead sign structures in accordance with the applicable provisions of Section 410 of the Standard Specifications. Construct footings for overhead sign structures in accordance with Section 825 of the Standard Specifications. Construct all footings with Class A concrete. Where rectangular forms are used, use forms that have a chamfer strip at all corners for at least that distance protruding above finished ground. Use chamfers, which measure 1 inch along the diagonal face.

Securely brace anchor bolts positioned in the form and hold in proper position and alignment. Provide a rubbed finish on concrete surfaces to be exposed above finished ground in accordance with Section 825-6 (D) of the 2006 Standard Specifications. Do not erect overhead sign structures on foundations until the concrete has reached a minimum compressive strength of 3000 psi. Determine concrete compressive strength by nondestructive test methods or compressive strength tests made in accordance with AASHTO T22 and T23. Furnish equipment used for nondestructive tests and obtain Engineer's approval before performing the tests.

D. Drilled Pier Construction

1. Excavation

Perform excavations for drilled piers to the required dimensions and lengths including all miscellaneous grading and excavation necessary to install the drilled pier. Depending on the subsurface conditions encountered excavation in hard rock, weathered rock or removal of boulders and debris may be required.

Dispose of drilling spoils as directed by the Engineer and in accordance with Section 802 of the 2006 Standard Specifications. Drilling spoils consist of all material excavated including water or slurry removed from the excavation either by pumping or with augers.

Construct drilled piers within the tolerances specified herein. If tolerances are exceeded, provide additional construction as approved by the Engineer to bring the piers within the tolerances specified. Construct drilled piers such that the axis at the top of the piers is no more than 3 inches in any direction from the specified position. Build drilled piers within 1% of the plumb deviation for the total length of the piers. When a grade beam is not required at the top of a pier, locate the top of pier elevation between 18 inches above and 6 inches above the finished grade elevation. Form the top of the pier such that the concrete is smooth and level.

If unstable, caving or sloughing soils are anticipated or encountered, stabilize drilled pier excavations with steel casing and/or polymer slurry. Steel casing may be either the sectional type or one continuous corrugated or non-corrugated piece. All steel casings should consist of clean watertight steel of ample strength to withstand handling and driving stresses and the pressures imposed by concrete, earth or backfill. Use steel casings with an outside diameter equal to the specified pier size and a minimum wall thickness of 1/4 inch. Extract all temporary casings during concrete placement in accordance with this provision unless the Contractor chooses to leave the casing in place in accordance with the requirements below.

Any steel casing left in place will be considered permanent casing. When installing permanent casing do not drill or excavate below the tip of the permanent casing at any time such that the permanent casing is against undisturbed soil. The Contractor may excavate a hole with a minimum diameter of 12 inches smaller than the specified size of the pier in order to facilitate permanent casing installation provided the sides of the excavation do not slough during drilling such that the hole diameter becomes larger than the inside diameter of the casing. Permanent steel casings are only allowed for full span overhead signs as approved by the Engineer and prohibited for cantilever overhead signs. No additional compensation will be paid for permanent casing. If the Contractor chooses to use permanent steel casing, include all casing costs in the "Footings for DMS-_Structure" pay item.

If the Contractor elects to use polymer slurry to stabilize the excavation, use one of the polymers listed in the table below:

PRODUCT	MANUFACTURER
SlurryPro EXL	KB Technologies Ltd 3648 FM 1960 West Suite 107 Houston, TX 77068 (800) 525-5237
Super Mud	PDS Company 105 West Sharp Street El Dorado, AR 71730 (800) 243-7455
Shore Pac GCV	CETCO Drilling Products Group 1500 West Shure Drive Arlington Heights, IL 60004 (800) 527-9948

Use slurry in accordance with the manufacturer's guidelines and recommendations unless approved otherwise by the Engineer. The Contractor should be aware that polymer slurry might not be appropriate for a given site. Polymer slurry should not be used for excavations in very soft or loose soils. If the excavation can not be stabilized with polymer slurry, the Engineer may require a site-specific subsurface investigation (if not done during design) and the use of steel casing. No additional time or compensation will be provided if both steel casing and polymer slurry are required to stabilize the excavation.

Construct all drilled piers such that the piers are cast against undisturbed soil. If a larger casing and drilled pier are required as a result of unstable or caving material during drilling, backfill the excavation before removing the casing to be replaced. No additional time or compensation will be provided for substituting a larger diameter drilled pier in order to construct a drilled pier cast against undisturbed soil.

Any temporary steel casing that becomes bound or fouled during pier construction and cannot be practically removed may constitute a defect in the drilled pier. Improve such defective piers to the satisfaction of the Engineer by removing the concrete and enlarging the drilled pier, providing a replacement pier or other approved means. All corrective measures including redesign as a result of defective piers will not be cause for any claims or requests for additional time or compensation.

2. Bottom Cleanliness

After a drilled pier excavation is complete and immediately before concrete placement, demonstrate acceptable bottom cleanliness of the drilled pier excavation to the Engineer for approval if the plans indicate end bearing was used in the design. Provide any equipment, personnel and assistance required for the Engineer to inspect the drilled pier excavation. The pier excavation bottom is considered clean if no portion of the bottom area has more than 3 inches of sediment as determined by the Engineer.

3. Reinforcing Steel

Completely assemble a cage of reinforcing steel consisting of longitudinal and spiral bars and place cage in the drilled pier excavation as a unit immediately upon completion of drilling unless the excavation is entirely cased. If the drilled pier excavation is entirely cased down to the tip, immediate placement of the reinforcing steel and the concrete is not required.

Lift the cage so racking and cage distortion does not occur. Keep the cage plumb during concrete placement operations and casing extraction. Check the position of the cage before and after placing the concrete.

Securely crosstie the vertical and spiral reinforcement at each intersection with double wire. Support or hold down the cage so that the vertical displacement during concrete placement and casing extraction does not exceed 2 inches.

Do not set the cage on the bottom of the drilled pier excavation. Place plastic bolsters under each vertical reinforcing bar that are tall enough to raise the rebar cage off the bottom of the drilled pier excavation a minimum of 3 inches.

In order to ensure a minimum of 3 inches of concrete cover and achieve concentric spacing of the cage within the pier, tie plastic spacer wheels at five points around the cage perimeter. Use spacer wheels that provide a minimum of 3 inches "blocking" from the outside face of the spiral bars to the outermost surface of the drilled pier. Tie spacer wheels that snap together with wire and allow them to rotate. Use spacer wheels that span at least two adjacent vertical bars. Start placing spacer wheels at the bottom of the cage and continue up along its length at maximum 10-foot intervals. Supply additional peripheral spacer wheels at closer intervals as necessary or as directed by the Engineer.

4. Concrete

Begin concrete placement immediately after inserting reinforcing steel into the drilled pier excavation.

(V) Concrete Mix

Provide the mix design for drilled pier concrete for approval and, except as modified herein, meeting the requirements of Section 1000 of the 2006 Standard Specifications.

Designate the concrete as Drilled Pier Concrete with a minimum compressive strength of 4500 psi at 28 days. The Contractor may use a high early strength mix design as approved by the Engineer. Make certain the cementitious material content complies with one of the following options:

- Provide a minimum cement content of 640 lbs/yd^3 and maximum cement content of 800 lbs/yd^3; however, if the alkali content of the cement exceeds 0.4%, reduce the cement content by 20% and replace it with fly ash at the rate of 1.2 LB of fly ash per LB of cement removed.

- If Type IP blended cement is used, use a minimum of 665 lbs/yd^3 Type IP blended cement and a maximum of 833 lbs/yd^3 Type IP blended cement in the mix.

Limit the water-cementitious material ratio to a maximum of 0.45. Do not air-entrain drilled pier concrete.

Produce a workable mix so that vibrating or prodding is not required to consolidate the concrete. When placing the concrete, make certain the slump is between 5 and 7 inches for dry placement of concrete or 7 and 9 inches for wet placement of concrete.

Use Type I or Type II cement or Type IP blended cement and either No. 67 or No. 78M coarse aggregate in the mix. Use an approved water-reducer, water-reducing retarder, high-range water-reducer or high-range water-reducing retarder to facilitate placement of the concrete if necessary. Do not use a stabilizing admixture as a retarder in Drilled Pier Concrete without approval of the Engineer. Use admixtures that satisfy AASHTO M194 and add admixtures at the concrete plant when the mixing water is introduced into the concrete. Redosing of admixtures is not permitted.

Place the concrete within 2 hours after introducing the mixing water. Ensure that the concrete temperature at the time of placement is 90°F or less.

(W) Concrete Placement

Place concrete such that the drilled pier is a monolithic structure. Temporary casing may be completely removed and concrete placement may be temporarily suspended when the concrete level is within 42 to 48 inches of the ground elevation to allow for placement of anchor bolts and construction of grade beam or wings. Do not pause concrete placement if unstable caving soils are present at the ground surface. Remove any water or slurry above the concrete and clean the concrete surface of all scum and sediment to expose clean, uncontaminated concrete before inserting the anchor bolts and conduit. Resume concrete pouring within 2 hours.

Do not dewater any drilled pier excavations unless the Engineer approves the dewatering and the excavation is entirely cased down to tip. Do not begin to remove the temporary casing until the level of concrete within the casing is in excess of 10 feet above the bottom of the casing being removed. Maintain the concrete level at least 10 feet above the bottom of casing throughout the entire casing extraction operation except when concrete is near the top of the drilled pier elevation. Maintain a sufficient head of concrete above the bottom of casing to overcome outside soil and water pressure. As the temporary casing is withdrawn, exercise care in maintaining an adequate level of concrete within the casing so that fluid

trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the drilled pier concrete. Exerting downward pressure, hammering or vibrating the temporary casing is permitted to facilitate extraction.

Keep a record of the volume of concrete placed in each drilled pier excavation and make it available to the Engineer.

After all the pumps have been removed from the excavation, the water inflow rate determines the concrete placement procedure. If the inflow rate is less than 6 inches per half-hour, the concrete placement is considered dry. If the water inflow rate is greater than 6 inches per half-hour, the concrete placement is considered wet.

- **Dry Placement: Before placing concrete, make certain the drilled pier excavation is dry so the flow of concrete completely around the reinforcing steel can be certified by visual inspection. Place the concrete by free fall with a central drop method where the concrete is chuted directly down the center of the excavation.**
- **Wet Placement: Maintain a static water or slurry level in the excavation before placing concrete. Place concrete with a tremie or a pump in accordance with the applicable parts of Sections 420-4 and 420-5 of the 2006 Standard Specifications. Use a tremie tube or pump pipe made of steel with watertight joints. Passing concrete through a hopper at the tube end or through side openings as the tremie is retrieved during concrete placement is permitted. Use a discharge control to prevent concrete contamination when the tremie tube or pump pipe is initially placed in the excavation. Extend the tremie tube or pump pipe into the concrete a minimum of 5 feet at all times except when the concrete is initially introduced into the pier excavation. If the tremie tube or pump pipe pulls out of the concrete for any reason after the initial concrete is placed, restart concrete placement with a steel capped tremie tube or pump pipe.**

Once the concrete in the excavation reaches the same elevation as the static water level, placing concrete with the dry method is permitted. Before changing to the dry method of concrete placement, remove any water or slurry above the concrete and clean the concrete surface of all scum and sediment to expose clean, uncontaminated concrete.

Vibration is only permitted, if needed, in the top 10 feet of the drilled pier or as approved by the Engineer. Remove any contaminated concrete from the top of the drilled pier and wasted concrete from the area surrounding the drilled pier upon completion.

(X) Concrete Placement Time

Place concrete within the time frames specified in Table 1000-2 of the 2006 Standard Specifications for Class AA concrete except as noted herein. Do not place concrete so fast as to trap air, water, fluids, soil or any other deleterious materials in the vicinity of the reinforcing steel and the annular zone between the rebar cage and the excavation walls. Should a delay occur because of concrete delivery or other factors, reduce the placement rate to maintain some movement of the concrete. No more than 45 minutes is allowed between placements.

E. Scheduling and Restrictions

If caving or sloughing occurs, no additional compensation will be provided for additional concrete to fill the resulting voids.

During the first 16 hours after a drilled pier has achieved its initial concrete set as determined by the Engineer, do not drill adjacent piers, do not install adjacent piles and do not allow any heavy construction equipment loads or "excessive" vibrations to occur at any point within a 20 foot radius of the drilled pier.

In the event that the procedures described herein are performed unsatisfactorily, the Engineer reserves the right to shut down the construction operations or reject the drilled piers. If the integrity of a drilled pier is in question, use core drilling, sonic or other approved methods at no additional cost to the Department and under the direction of the Engineer. Dewater and backfill core drill holes with an approved high strength grout with a minimum compressive strength of 4500 psi. Propose remedial measures for any defective drilled piers and obtain approval of all proposals from the Engineer before implementation. No additional time or compensation will be provided for losses or damage due to remedial work or any investigation of drilled piers found defective or not in accordance with these Project Special Provisions or the Plans.

24.4. MEASUREMENT AND PAYMENT

Footings for DMS structure will be measured and paid as the actual number of cubic yards of concrete that has been incorporated into the completed and accepted footing. Computing the number of cubic yards of concrete will be done from the dimensions shown in the Plans or from revised dimensions authorized by the Engineer, calculated to the nearest 0.01 of a cubic yard.

Payment will be made under:

Footings for DMS Structure ..... Cubic Yards

25. DMS DIRECT TENSION INDICATORS

25.1. General

Use direct tension indicators on all ASTM A325 high strength bolt connections in DMS structures.

Provide direct tension indicators that conform to these Project Special Provisions, the requirements of ASTM F959 and the manufacturer's recommendations.

25.2. Material Requirements

Use direct tension indicators whose material, manufacturing process, performance requirements, workmanship and certification requirements conform to the requirements of ASTM F959.

For Type 3 high strength bolts, use direct tension indicators mechanically galvanized to ASTM B695 Class 50, then with 1 mil of baked epoxy applied.

For plain Type 1 high-strength bolts, use direct tension indicators that are plain or mechanically galvanized to ASTM B695 Class 50.

For galvanized Type 1 high strength bolts, use direct tension indicators that are mechanically galvanized to ASTM B695 Class 50 only.

25.3. Test Documents

Furnish the Engineer with a copy of the manufacturer's test report for each lot of direct tension indicators used in the project. The manufacturer must perform these tests according to the requirements of ASTM F959. Include in each test report the lot number of the indicators, manufacturer's name, tension load when indicators were tested, gap clearance, nominal size, coating thickness, date tested, and name and location of the company that performed the tests.

Furnish the Engineer with a copy of the manufacturer's instructions for installing the direct tension indicators before installation begins along with at least 1 metal feeler gauge for each 50 direct tension indicators shipped.

Use only direct tension indicators whose container lot numbers match the lot numbers on the test documents.

25.4. Required Test Samples

Furnish the Engineer with three samples of load indicating washers from each lot number, size and type for departmental tests along with two of the metal feeler gages required for performing the tests.

25.5. Construction Methods

A. Installation

Install the direct tension indicators in strict compliance with the manufacturer's written instructions.

Install the direct tension indicator under the bolt head normally. If it is necessary to install the direct tension indicator under the nut, or if the bolt head must be turned, install additional hardened

washers in accordance with the manufacturer's instructions. Have a tension-indicating device on the project for determining the tension imposed on a fastener when the protrusions on direct tension indicator have been properly compressed.

Test three samples from each lot of direct tension indicators in the presence of the Engineer. Achieve a minimum bolt tension 5 percent greater than that required by Table 440-1 in Article 440-10 of the Standard Specifications. Do not substitute direct tension indicators for the hardened steel washers required with short slotted or oversized holes, but you may use them in conjunction with them.

Initially install the direct tension indicators to a snug tight condition as specified in Section 440-10 Paragraph (C) (3) of the Standard Specifications. After the initial tightening, fully tighten the fasteners, as recommended by the manufacturer of the direct tension indicators, beginning at the most rigid part of the joint and continuing toward its free edges.

Use a wrench to tighten fasteners containing direct tension indicators of the type and capacity recommended by the manufacturer and which is clean and lubricated. Use an air supply and hoses that are in good condition and provide air pressure of at least 100 psi at the wrench.

Perform any heating of structural steel required for corrections in the vicinity of fasteners before direct tension indicators are installed.

B. Inspection

The Engineer will inspect for correct tightening of bolts by inserting a 0.005 inch thickness feeler gauge into the openings between adjacent flattened protrusions of the direct tension indicator. The tension is correct when the number of spaces the gage can not enter is equal to or greater than the value shown in the table below.

Number of Spaces in Washer	Number of Spaces Gage is Refused
4	2
5	3
6	3
7	4

The gage must not be able to enter any spaces when the direct tension indicator is used under the turned element.

Do not tighten bolts to a no visible gap condition. Replace bolts that have a direct tension indicator with no visible gap and tighten the bolts with a direct tension indicator.

The Engineer will inspect at least 10 percent, but no less than 2, of the bolts in each connection, using the metal feeler gages provided by the Contractor.

Ensure that the part of the fastener being restrained from turning does not rotate during the tightening process, thereby abrading away a portion of the direct tension indicator protrusions.

Ensure that none of the direct tension indicator protrusions are accidentally partially flattened before installing in the structural steel joints.

Do not reuse direct tension indicators. If it becomes necessary to loosen a bolt previously tensioned, discard and replace the direct tension indicator.

25.6. MEASUREMENT AND PAYMENT

There will be no direct payment for the work covered by this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for the DMS structure and will be full compensation for all work listed above.

26. DMS DOCUMENTS AND SUBMITTALS

26.1. GENERAL

The submittals listed below complement requirements stated throughout these Project Special Provisions and do not replace them.

Provide all drawings on 22" X 34" sheet of paper unless approved by the Engineer otherwise. The drawing must fill the entire sheet of paper excluding a 2" border all around.

Allow 30 days for all documentation and submittal reviews unless otherwise stated in these Project Special Provisions. Supplement each drawing by catalog cut sheets and parts list. Provide parts list in the following format:

Part ID	Source	Part number	Alternate source	Alternate Part number	Description

26.2. DRAWINGS AND DOCUMENTS' CERTIFICATION

Provide the following drawings, documents, plans, and calculations approved by a Professional Engineer registered in the state of North Carolina that bears his/her signature, seal, and date of acceptance:

- Plans for the DMS enclosure, mounting description, and shop drawings.
- Plans for overhead sign assemblies, footings, design computations and shop drawings.
- Electrical power distribution drawings and power consumption calculations.

26.3. MECHANICAL

This set of submittals includes, but is not limited to, material specifications, catalog cut sheets, parts list, and fabrication drawings for DMS controller cabinet(s), DMS enclosure, character assemblies, DMS overhead assemblies, DMS to DMS overhead assemblies mounting, and etc. Engineering calculations must accompany drawings as needed and applicable.

26.4. ELECTRICAL

This set of submittals includes, but is not limited to, material specifications, catalog cut sheets, parts list, and wiring diagrams within the DMS controller cabinet, DMS enclosure, DMS controller cabinet/enclosure, service entrance cabinet/panels, and etc. This set of submittals also includes power consumption calculations, wire and conduit size calculations, voltage drop calculation, and etc. The DMS electrical system: wires, conduits, breakers, panel-boards, and etc. must meet the latest edition of NEC requirements.

26.5. Electronics

This set of submittals includes, but is not limited to, material specifications, catalog cut sheets, parts list, and schematic diagrams for all electronics assemblies and sub-assemblies used in the system.

26.6. Block Diagrams

Provide block diagrams for the following:

- DMS System
- DMS Controller Cabinet
- DMS Enclosure
- DMS Controller
- DMS Display Boards
- DMS Driver Board(s)
- DMS Lighting Control Board(s)
- Interface Board(s)
- And other system's boards/assemblies that help in understanding, troubleshooting, and repairing the system and/or system's components.

26.7. LEDs

This set of submittals includes LED data/specification sheets and the LED selection procedure as required elsewhere in these Project Special Provisions.

26.8. Bench Repair Documentation:

After approval of any equipment or equipment component parts and prior to installation of the equipment, supply all schematics drawings, board layout information, equipment manuals, software, and firmware required to perform bench repair to the component level and testing of electronic equipment and equipment circuit boards. Failure to supply the documentation required by this Section will be grounds for rejection of the submitted item. Provide schematic drawings as well as the board layout drawings that identify all components in the equipment or circuit board including but not limited to all digital and analog integrated circuits devices (ICs), all discrete electronic components, transformers, relays, and other electronic devices and components used in the circuits. Provide schematic drawings that show pin to pin interconnection between components. Provide a complete parts list for each circuit board's components. Provide a copy of all software required to operate any equipment or circuit boards for the purposes of test or system software to test operation of equipment used as a system component.

26.9. Proprietary Parts

Provide a list of all proprietary, non-warranty electronic component parts, along with its associated cost, at which the vendor will supply for a two year period after final project acceptance. Failure to supply this required proprietary part and price information may be grounds for rejection of the submitted item due to incomplete information. A part is considered to be a proprietary part if it is designed and manufactured exclusively for a specific application and is not commercially available for sale to the general public. In addition, any item that is sole source (e.g. available only from the vendor or from a single known manufacturer) is considered to be proprietary and should be identified along with the sole source. Identify and quote a price for parts that are no longer being manufactured and identify the item as one that is no longer manufactured.

26.10. Use by NCDOT and Protection of Manufacturer's Proprietary Information

NCDOT Traffic Electronics Center electronics technicians will use the above documentation (schematics, drawings, software, firmware, manuals, etc.) exclusively for the following purposes: diagnosing and performing repairs on malfunctioning equipment, equipment circuit boards, and malfunctioning systems; operational test of repaired equipment, circuit boards, systems; and performing authorized upgrades to equipment, circuit boards, and software supplied under this contract. NCDOT Traffic Electronics Center electronics technicians will not use or copy devices or software for any purpose other than diagnosis, repair, and testing or to perform authorized firmware or software upgrades.

Upon notification by the manufacturer, the Department agrees not to divulge any proprietary or otherwise confidential information contained in the above required documentation. The Transportation Mobility and Safety Division of NCDOT agrees to protect and secure any proprietary documentation identified by the manufacturer as proprietary or confidential. Upon request by the manufacturer, Transportation Mobility and Safety Division of NCDOT agrees to sign a binding non-disclosure agreement with the manufacturer or other business that is providing documentation it considers proprietary or otherwise confidential.

26.11. Measurement and Payment

There will be no direct payment for the work covered by this section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit price for the DMS and will be full compensation for all work covered in this section.

27. CENTRAL HARDWARE AND SOFTWARE CONFIGURATION

27.1. DESCRIPTION

Edit the database of the existing graphical user interface and existing VideoPro central CCTV software controlling the video matrix switch to add the additional CCTV devices and update the map coverage (list locations where contractor is to edit the database). Copy the database to and install the software on the existing video server and configure the existing video switch.

27.2. CONFIGURATION

A. Central CCTV Software

The existing CCTV central software that controls the existing video matrix switch at the TRTMC is Protronix's VideoPro. It also interfaces with a DVR. This software includes on-screen pan-tilt-zoom controls of each camera in the system.

Modify the Protronix CCTV central software configuration at the TRTMC to display and map the new and relocated CCTV devices so that the CCTV video can be displayed on the existing monitors and display devices at (list).

Integrate with NCDOT's regional video sharing and distribution system to allow for:

- Remote Users to view and control CCTV units that terminate on the NCDOT analog video matrix switch through the Ethernet network connection between the two centers and the CCTV Control GUI furnished as part of this Software.
- Users on the NCDOT regional video system shall be able to access and control CCTV units that reside on the Remote Users' Ethernet network via the LAN connection between the TRTMC and the Remote User. This shall be accomplished through modification of the existing VideoPro software to permit the control of Remote User CCTV unit via the VPE GUI and the transmission of CCTV video over the center to center Ethernet connection and the Video decoders called for under this project.

27.3. MATERIALS

A. Rack Cabinets

As called for at the TRTMC, furnish and install rack cabinets with railings and sockets for mounting of EIA 19" mountable equipment. Furnish rack cabinets with removable and adjustable shelves and pull out drawers capable of holding 1.5 times the heaviest component required to be placed on shelf or drawer (when fully extended). Furnish rack cabinets that are modular with removable side panels with open front and back sections. Furnish rack cabinets with cable management and raceways to facilitate neat and orderly organization of all cables routed to equipment on the rack. Furnish rack cabinets with accessories to ensure cables are not kinked or pinched and that all minimum bend radii of cables are preserved. Furnish rack cabinets that may be aggregated into single units of up to four bays wide. Furnish rack cabinets with ventilation fans audible no more than 46 dba at a distance of 4 feet from the unit. Furnish rack cabinets with each bay a width of no more than 24" and a minimum of 84" of continuous useable rack space beginning no more than 6" above the floor. Furnish rack cabinets with maximum height of no more than 12" less than the ceiling of the room they are to be installed in. Furnish rack cabinets made of quality, non-corrosive materials and non-pealing paint. Furnish rack cabinets that are same color and same manufacturer.

Equip each rack with a rack-mount uninterruptible power supply (UPS) units capable of detecting a power failure and providing back-up power to the components plugged into within twenty (20) milliseconds. The transition to the UPS source from primary power shall occur without loss of data or damage to the equipment being provided with back-up power.

Furnish UPS units that are sized such that each is capable of providing back-up power for the total load of all equipment connected to the UPS plus an additional load of twenty-five percent of the total load for at least ten (10) minutes of operation. Furnish minimum of one UPS unit per newly furnished equipment rack up to the number required to meet the back-up time requirement for the load for the equipment on the rack.

Furnish UPS units that act as surge and power transient suppression devices that meet or exceed the surge suppression requirements of Underwriter's Laboratory standards UL 1449 and UL 1778.

Furnish UPS units that shall be capable of interfacing with management software resident on application servers capable of initiating a device shutdown based on user adjustable parameters. The software shall also be able to interrogate each unit regarding remaining battery load. Furnish UPS units that can be integrated into computing and network devices via a 10Bast-T LAN connection and contain a RJ-45 port and network interface card to facilitate such connection. The UPS shall communicate using TCP/IP unless otherwise approved by the Engineer and shall be IP addressable. Furnish UPS units with a serial RS-232 serial port for direct connection to a computer. All software provided shall operate in a Windows 2000 environment unless otherwise approved by the engineer.

Furnish UPS units with the following characteristics:

- Commercial 115 VAC, 60 Hz power interconnection and power loss sensing and alarm reporting
- Power protection and filtering
- Power conversion for battery charging
- Battery status sensing and low battery alarm reporting
- Battery charging and charge management
- Battery power conversion and filtering as necessary for interface compatibility with installed equipment
- Compliance with article 645 of the National Electric Code (NEC)
- Operating temperature Range — 32 Degrees F to 105 Degrees F
- Humidity — 0%-95%, non-condensing
- Size — less than 5.25" (3RU) tall
- Surge energy rating — greater than 480 joules
- Electrical outlets — 6 NEMA 5-15R

27.4. CONSTRUCTION METHODS

The Contractor shall upgrade existing servers and server software for MVD and DMS systems to allow for IP/Ethernet communications installed under this Project.

Install a new rack cabinet at the TRTMC as shown on the Plans.

27.5. MEASUREMENT AND PAYMENT

___ *hardware and software configuration* for the editing of the databases and integrating of the new CCTV devices will be measured and paid for at the contract lump sum price. The price and payment will be full compensation for all work required by this section, including the furnishing, testing and all materials, equipment including rack cabinets, labor, tools, storage, shipping and incidentals necessary to edit the existing system configuration to add the new CCTV devices.

Payment will be made under:

Division 9 Hardware and Software Configuration .....Lump Sum
TRTMC Hardware and Software Configuration .....Lump Sum

28. TESTING & ACCEPTANCE

28.1. DESCRIPTION

This section describes the testing and acceptance requirements of all ITS devices beign installed with the exception of DMS assemblies and related equipment. DMS testing is described in the "DMS Testing Requirements" section of these Project Special Provisions.

Conduct and complete successfully the following progressive series of tests before acceptance: factory acceptance testing, field demonstration test prior to installation, installed standalone tests, system test of the network hardware, management software and an operational test. Develop a comprehensive series of test plans for each device to determine the equipment was correctly installed and meets the requirements of materials, workmanship, performance and functionality required in the Plans and Project Special Provisions. The test plans shall describe the functions to be tested, purpose of test, setup requirements, procedures to be followed, any inputs and expected outputs for each test, criteria for pass/fail and any required tools or test equipment. Any software testers shall be pre-approved by the Department.

Develop as part of the Test Plan a Traceability Matrix of all the individual subsystem functional requirements to be used to cross-reference each planned test to a specific contract requirement to be verified. This Test Evaluation/Traceability Matrix shall be used by the Engineer to crosscheck the functional requirements and the results.

A key element of test plans, where appropriate, is the introduction of forced errors into the functional test. The test plan shall check the actual result of the forced error against the anticipated result. Test will be performed by the Contractor and witnessed by the Department. No deviation from the written test procedure shall be permitted without approval from the Engineer. Any changes to the approved test procedure to accommodate unforeseen events during the time of testing shall be documented in a copy of the master test procedure. Immediately following the conclusion of each test, the Department and the Contractor shall meet to agree on the results observed and recorded during the testing. This will form the basis for the conclusions reported in the test plan. All test results, notes, and observations shall be maintained in both electronic and hard copy. Maintain complete records of all test results during all stages of testing.

28.2. FACTORY ACCEPTANCE TESTING (FAT)

Conduct a factory acceptance test to verify to the Department that all design, materials, and performance requirements for this project are satisfactorily met. Perform the factory acceptance tests at the equipment manufacturer's facility or at an independent testing laboratory.

28.3. PRE-INSTALLATION FIELD DEMONSTRATION TESTING (FDT)

Conduct pre-installation field demonstration tests (FDT) on all devices at a Contractor-provided facility within Forsyth County. Perform the tests on all components supplied to verify that no damage was done to any unit during the shipment and delivery process. Notify the Engineer a minimum of 15 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this section. Each device shall pass the individual tests detailed below prior to installation.

Establish a local test facility to setup, program and test the ITS device controllers before installation.

A. Product Examination Test

Examine each device carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

B. Continuity Test Specifications

Check the wiring to determine conformance with the applicable standards, specifications, and requirements.

C. Operational Test Specifications

Operate each device long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

D. Pre-installation Test Failure Consequence

If any unit fails to pass a FDT, the unit shall be corrected or another unit substituted in its place, and the test successfully repeated.

If a unit has been modified as a result of an FDT failure, prepare a report and deliver that report to the Engineer prior to the unit's shipment. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops (more than two failures), the Engineer will make a determination of the disposition of the failed equipment without additional cost to the Department or an extension of the contract period.

28.4. INSTALLED SITE TESTS

Conduct an approved, standalone equipment installation test at the field site. Test all standalone functions of the field equipment using equipment installed as detailed in the Plans, or as directed by the Engineer.

Complete approved test plan forms and turn them over to the Engineer for review as a basis for rejection or acceptance. Provide a minimum notice of 30 calendar days prior to all tests to permit the Engineer or his representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a standalone test failure, prepare a report describing the nature of the failure and the corrective action taken and deliver it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the contract period.

Utilize vendor supplied device software to perform diagnostic tests of each device. The vendor supplied diagnostic software shall be provided to the Department before final acceptance. Test the following features of each competent as described below.

A. Fiber-Optic Cable

Conduct optical time domain reflectometer (OTDR) tests on the cable on the reel and after the cable is installed and terminated. Provide written notification a minimum of ten days before beginning fiber-optic cable testing.

After splicing is completed, perform bi-directional OTDR tests on each fiber, including unused fibers, to ensure the following:

- Fusion splice loss does not exceed 0.05 dB,

- Terminations and connections have a loss of 0.5 dB or less, and
- Reflection loss is 40 dB or greater for each connector.

Install a 1000-foot pre-tested launch cable between the OTDR and fiber-optic cable to be tested.

If exceeded, remake splices until the loss falls below 0.05 dB. The Department will record each attempt for purposes of acceptance.

Furnish durable labeled plots and electronic copies on a CD or DVD of test results for each fiber including engineering calculations demonstrating that OTDR test results meet or exceed the attenuation requirements and that optical properties of the cable have not been impaired. Label all test results (plots and discs) with the manufacturer and model number of the OTDR testing equipment.

Provide a tabular summary or spreadsheet detailing and comparing the loss budget and actual loss calculations per link. Provide test results for fiber-optic cable that demonstrates the loss budget where the fiber originates and the point where the fiber meets an electronic device.

If any fiber exceeds the maximum allowable attenuation or if the fiber-optic properties of the cable have been impaired, take approved corrective action including replacement of complete segments of fiber-optic cable if required. Corrective action will be at no additional cost to the Department.

B. CCTV Field Equipment

Develop an operational test plan that demonstrates all requirements of the equipment and software. Submit for approval before conducting tests.

Notify the Department at least 14 calendar days prior to the proposed date for the tests. The Department shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

Perform the following local field operational tests at the camera assembly field site in accordance with the test plans. A laptop computer shall provide camera control and positioning. After completing the installation of the camera assembly, including the camera hardware, video codec unit, power supply, and connecting cables:

- Furnish all equipment, appliances, and labor necessary to test the installed cable and to perform the following tests before any connections are made;
- Verify that physical construction has been completed;
- Inspect the quality and tightness of ground and surge protector connections;
- Check the power supply voltages and outputs;
- Connect devices to the power sources;
- Verify installation of specified cables and connections between the camera, PTZ, camera control receiver, and control cabinet;
- Perform the CCTV assembly manufacturer's initial power-on test in accordance with the manufacturer's recommendation;
- Set the camera control address;
- Verify the presence and quality of the video image with a portable NTSC-approved monitor;
- Exercise the pan, tilt, zoom, focus, iris opening, and manual iris control selections, and the operation, preset positioning, and power on/off functions;

- Demonstrate the pan and tilt speeds and extent of movement to meet all applicable standards, specifications, and requirements;
- Verify proper voltage of all power supplies; and
- Interconnect the communication interface device with the communication network's assigned fiber-optic trunk cable and verify that there is a transmission LED illuminated.
- Verify that the video codec unit is properly encoding the video from the field camera

Repair or replace defective or failed equipment and retest.

C. MVD Field Equipment

Develop an operational test plan that demonstrates all requirements of the equipment and software. Submit for approval before conducting tests.

Notify the Department at least 14 calendar days prior to the proposed date for the tests. The Department shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

Perform the following local field operational tests at the MVD assembly field site in accordance with the test plans. After completing the installation of the MVD assembly, including the detector unit, power supply, and connecting cables:

- Furnish all equipment, appliances, and labor necessary to test the installed MVD and to perform the following tests before any connections are made;
- Verify that physical construction has been completed;
- Inspect the quality and tightness of ground and surge protector connections;
- Check the power supply voltages and outputs;
- Connect devices to the power sources;
- Verify installation of specified cables and connections to the detector;
- Perform the manufacturer's initial power-on test in accordance with the manufacturer's recommendation;
- Set the detection zones;
- Verify the presence and quality of detection data;
- Verify proper voltage of all power supplies; and
- Interconnect the communication interface device with the communication network and verify that there is transmission.

Repair or replace defective or failed equipment and retest.

D. Truck Rollover System

Develop an operational test plan that demonstrates all requirements of the equipment and software. Submit for approval before conducting tests. The test plan shall have procedures to demonstrate that the system does not have a high percentage of false positive readings.

Notify the Department at least 14 calendar days prior to the proposed date for the tests. The Department shall have the right to witness such tests, or to designate an individual or entity to witness such tests.

Perform the local field operational test and repair or replace defective or failed equipment and retest.

E. Spread Spectrum Radios

Test the spread spectrum radios as follows:

- Check all ground, power, data, Ethernet and analog video connections,
- Run power up self test on each piece of equipment,
- Run all available vendor-supplied self-diagnostics,
- Check received signal strength, noise levels, bandwidth, and accuracy of test data transmission between each pair of nodes,
- Adjust hopping patterns as necessary to maximize the quality of the signal strength,
- If adjusting the hopping pattern does not significantly improve the quality of the signal strength, then adjust antenna as necessary to maximize the quality of the signal strength, and
- Test the transmission of data to ensure the transmission of data from spread spectrum radios. Run the system diagnostics from end to end.

28.5. SYSTEM OPERATIONAL TEST

A. General

Conduct tests as described below of the system from the user perspective at the TRTMC, Division 9 Office, and City of Winston-Salem. Conduct approved subsystem tests on the field equipment with the central equipment including, at a minimum, all remote communications hardware monitoring and control functions. These tests shall be a demonstration of overall system stability. During this test period, limit downtime due to mechanical, electrical, or other malfunctions to a maximum of 8 hours. The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of 8 hours.

Conduct device and subsystem tests of any repaired or replaced equipment.

The Engineer has the right to suspend the test to correct deficiencies and restart the test or to extend the test period by time equal to the downtime in excess of 8 hours. If a component has been modified as a result of a test failure, prepare a report and deliver it to the Engineer prior to retesting.

Perform the following subsystem tests from each of the central sites:

- Verify that new and existing CCTV cameras can be selected in the user GUI, controlled by the users' joystick or keyboard/mouse, and the video displayed on the proper monitor.
- Verify that new MVD units can be polled for system status and display real-time data.
- Verify that the new Truck Rollover System can be polled for system status and display historical data.

28.6. OBSERVATION PERIOD

Upon successful completion of the System Operational Test and the correction of all known deficiencies, including minor construction items and punch-list items developed by the Engineer, a 60 day Observation Period shall commence. The purpose of this period is to determine that all components of the system function in accordance with the Plans and these Project Special Provisions over an extended length of time.

System or component failures that occur during the 60 day Observation Period shall be responded to by the Contractor within two (2) hours, and corrected within twenty-four (24) hours. Failures that affect any of the major system components defined below for more than seventy-two (72) hours shall suspend the timing of the 60 day Observation Period beginning at the time when the failure occurred. After the cause of such failures has been corrected, timing of the 60 day observation period shall resume. System or component failures that necessitate a redesign of any component, and failures in any of the major system components exceeding a total of three (3) like major system components in any thirty (30) day period for the entire complement of major system components, shall terminate the 60 day Observation Period and shall cause the 60 day Observation Period to be restarted from zero when the redesigned component has been installed and/or the failures corrected.

The 60 day Observation Period is considered to be a part of the work included in the total contract time and must be completed prior to acceptance of the Project. All documentation required by these Project Special Provisions shall be completed prior to the end of the 60 day Observation Period.

Final Acceptance will occur at the successful completion of the 60 day Observation Period and after all documentation requirements have been fully satisfied.

28.7. FINAL ACCEPTANCE

After all equipment and software comprising the system has been accepted, satisfactory completion of the system acceptance test, and after the training is complete, a 60-day observation period begins. This observation period shall serve to evaluate full-scale operation of the system under normal conditions. NCDOT will be responsible for operating the system during this period. The goal of the observation period is to demonstrate that the system has been properly installed and integrated, performs properly, and complies with the Contract Documents.

Upon successful completion of the observation period, the Department will accept the system, providing that all errors and omissions in documentation supplied have been fixed, and all other requirements of the Contract Documents have been met. Final acceptance will be in writing from the Department.

28.8. MEASUREMENT AND PAYMENT

There will be no direct payment for testing and the work covered by this Section.

Payment for this work will be covered in the applicable sections of these Project Special Provisions at the contract unit prices as called for under each applicable section and will be full compensation for all work covered in this section.

29. TRAINING

29.1. DESCRIPTION

Provide training for the installation, operation and maintenance of the system.

29.2. MATERIALS

Provide training to properly install, operate, maintain, diagnose and repair each piece of equipment and the software associated with the system. Provide approved manufacturer's representatives or other qualified personnel to conduct training courses. Provide training for a minimum of fifteen Department personnel.

Prior to beginning the training course, submit detailed course curricula, draft manuals, handouts, and resumes of the instructors for review and approval. The Engineer may request modification of the material and request courses desired by the Department.

For all training programs, a staff of engineers, technicians, and maintenance personnel familiar with the installed systems will be the training participants. A "day" of training shall consist of training conducted between the hours of 8:30am and 4:30 pm. For each session, provide training materials (manuals, notebooks, hand-outs, etc.) as specified in the Documentation Section of these Project Special Provisions.

Qualified instructors shall present all training courses, lectures, and demonstrations in person. The Engineer shall approve all instructors.

Unless otherwise specified, accommodate a minimum of fifteen (15) persons at each session. Limit all hands-on computer exercises to two participants per computer. Furnish additional networked computers (equivalent to those furnished with the project) as necessary to maintain that ratio of two participants per computer.

Conduct all training courses at a location provided by the Department and at a time mutually agreed upon, but not later than the start of system acceptance testing. Provide training material, manuals, and other handouts to serve not only as subject guidance, but also as quick reference for use by the students. Deliver course material in reproducible form immediately following the course.

A. Subject Areas

Provide the training sessions at the required durations as listed in the Table below. A more detailed description of the required content of each training session is provided in the following sections. As part of the Project Implementation Schedule, propose the time of occurrence of each such training schedule.

Subject	Minimum Duration
System Overview	0.5 Day
Ethernet LAN and Peripherals	1 Day
Wireless Radio Communications System	0.5 Day
Truck Rollover System	0.5 Day

B. Required Content and Format

1. System Overview

This training session shall consist of a lecture and discussion on the overall. The purpose of the session is to provide an overview of the system. This training session shall have a minimum duration of one half (0.5) day.

2. Ethernet LAN and Peripherals

The training session shall consist of classroom workshops regarding the operation of each of the Ethernet LAN elements and the operator interface. Conduct training by experienced vendor personnel.

The session shall involve the operation and maintenance procedures for each element of the system. As part of this session, stress the precautions that must be observed when operating the equipment. As a minimum, cover the following subjects in this segment of the training session:

- IP/Ethernet theory, configuration, and network management
- Functional operation of the equipment
- Operating system, including network operating system
- Troubleshooting and problem identification of equipment.
- Detection of abnormal conditions within the operating system and hardware

This training session shall have a minimum duration of one (1) day of workshops.

3. Wireless Radio Communications System

The training session shall consist of classroom workshops regarding the operation of the wireless radio system and the operator interface. Conduct training by experienced vendor personnel.

The session shall involve the operation and maintenance procedures for each element of the system. As part of this session, stress the precautions that must be observed when operating the equipment. As a minimum, cover the following subjects in this segment of the training session:

- Overview of equipment functions and interactions.
- Functional operation of the equipment
- Operating system, including network operating system
- Troubleshooting and problem identification of equipment.
- Detection of abnormal conditions within the operating system and hardware

This training session shall have a minimum duration of one half (0.5) day of workshops.

4. Truck Rollover System

The training session shall consist of classroom workshops regarding the maintenance and operation of the truck rollover system. Conduct training by experienced vendor personnel.

The session shall involve the operation and maintenance procedures for each element of the system. As part of this session, stress the precautions that must be observed when operating the equipment. As a minimum, cover the following subjects in this segment of the training session:

- Overview of equipment functions and interactions.
- Functional operation of the equipment
- Troubleshooting and problem identification of equipment.
- Detection of abnormal conditions within the operating system and hardware

This training session shall have a minimum duration of one half (0.5) day of workshops.

29.3. MEASUREMENT AND PAYMENT

Training will be paid for as the lump sum price. Such lump sum price will be full payment for all material covered in this section including, but not limited to, cost for instructors, visual equipment, computers, transportation, lecture material, and any other items necessary to provide training as described in these Project Special Provisions.

Payment will be made under:

Training.....Lump Sum